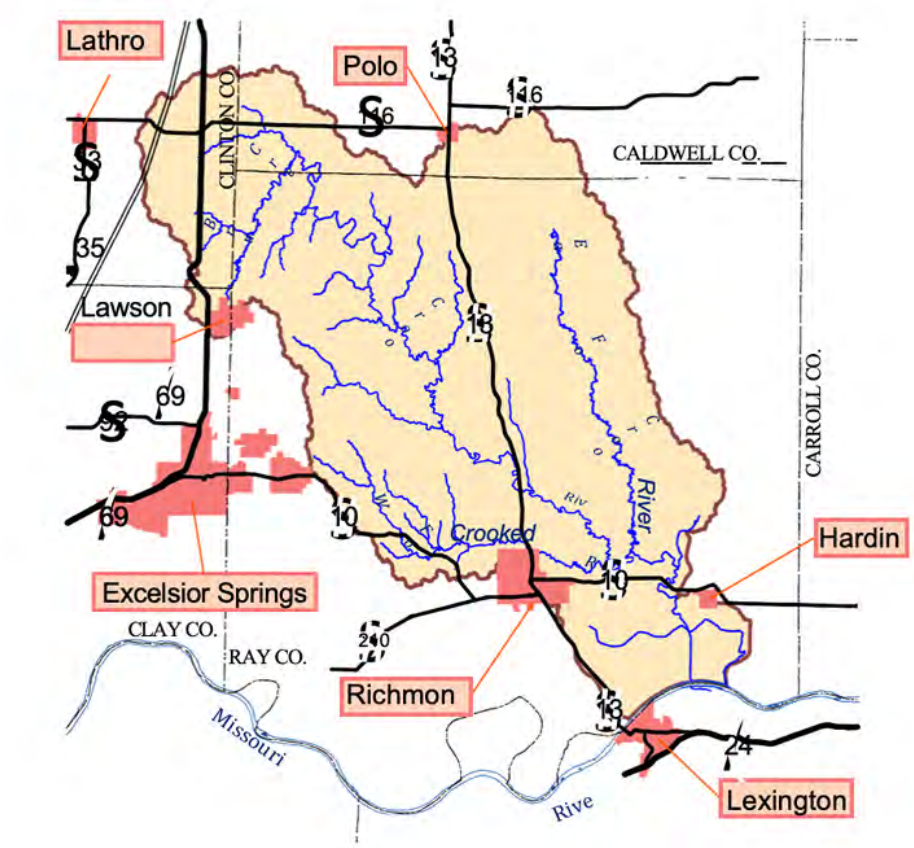

Crooked River

Watershed and Inventory Assessment

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Acknowledgements

I wish to thank several individuals who provided assistance on this document. Thanks to Harold Kerns for his guidance and knowledge of area resources and the basin planning process. Vince Travnichek provided valuable assistance in sampling, proof reading, and advice during the basin planning process. Debbie Banks helped with sampling and worked diligently on stream gradients, channelization, and other map related information in the basin. Dave Seibel was a great help in sampling and filming the basin.

Scott Ryan helped in locating sampling sites, familiarization with basin streams, and sampling in the basin. The personnel of the Ray County Natural Resources Conservation Service were most helpful and courteous in providing information pertaining to the Crooked River basin. Marilyn Taylor of the St. Joseph Museum was helpful in documenting historical information. Mike George provided useful background information on native inhabitants that were in the area before and during settlement. Thanks also to Missouri Department of Conservation personnel and other contributors too numerous to mention.

Executive Summary

The Crooked River is a sixth order river located east of Kansas City, Missouri. The Crooked River originates north of Lawson, Missouri and flows southeastward for about 70 miles where it empties into the Missouri River south of Hardin, Missouri. The watershed drains 335 square miles. The Crooked River basin lies near the transition area between the glaciated plains and the Osage plains. The average annual discharge for the Crooked River measured at Richmond, Missouri (48% of the basin) is 99 cubic feet per second. There are 59 third order and larger streams within the basin. Major tributaries of the Crooked River are East Fork Crooked River and West Fork Crooked River. Drainages in the lower two-thirds of the basin are turbid and silt laden. Drainages in the upper third of the basin are rocky and clear.

The basin is rural with Richmond (population 5,738; 1990 U.S. Census) being the largest city in the watershed. Population in the basin is growing as Kansas City suburbs expand. Land use in the basin is dominated by agriculture. Only one percent (2,182 acres) of the watershed is in public ownership.

Water quality is affected by soil erosion, sediment deposition, turbidity, nutrients, and periodic low dissolved oxygen concentrations. The majority of livestock have access to streams in the basin potentially increasing bank erosion and nutrient levels. Coal was mined from the 1870's to the 1950's. Most of the basin is underlain by the Lexington coal field and may be mined again in the future. These non-point sources of pollution are the major threat to the diversity and abundance of aquatic fauna. Less channelization has occurred in the basin, when compared with other basins in Northwest Missouri. Point source pollution concerns come from wastewater treatment facilities located near the communities of Lawson, Richmond and Polo. Increasing numbers of confined animal feeding operations are a new threat to basin streams.

Forty species of fish have been collected in the basin from 1941 to 1998. Topeka shiners were collected in 1965, but not in 1995 or 1998 samples and are assumed to have been extirpated from the Crooked River basin. In recent surveys, wide ranging, tolerant species were the most commonly sampled fish, with minnows from the Cyprinidae family the most prevalent. Statewide creel surveys from 1969 indicated that common carp, bullhead and channel catfish are the most frequently harvested fish. Recent angler and creel surveys for the Crooked River basin are lacking.

Private ownership accounts for 99% of basin lands, making private landowners the critical link in improving stream habitat and water quality. The main objective is to increase public awareness and responsibility in improving the stream resources within the basin. This would allow the goals in this plan to be met. The main goals are: Improve water quality and quantity, improve riparian and aquatic habitats, maintain diverse and abundant populations of native aquatic organisms, meet angler demand for quality fishing, increase public appreciation for stream resources and increase recreational use.

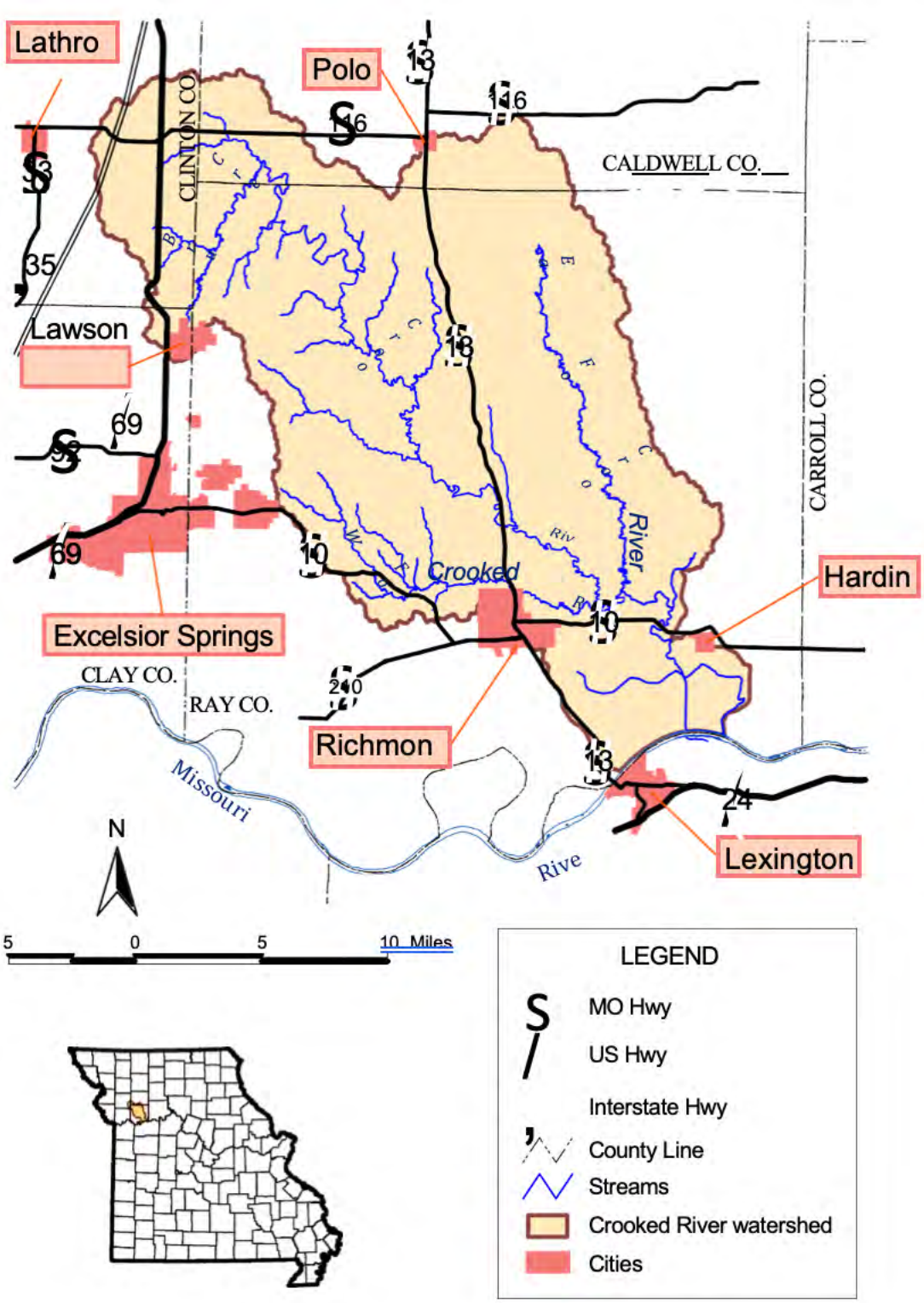
Location

The Crooked River originates just north of the community of Lawson, Missouri. The mainstem river flows in a southeasterly direction and confluences with the Missouri River about three miles south of Hardin, Missouri (Figure 1). The major tributaries of the Crooked River are the East Fork Crooked River (headwaters near Polo, Missouri) and West Fork Crooked River (headwaters near Excelsior Springs, Missouri) which join the mainstem Crooked River about four miles east of the town of Richmond, Missouri. The Crooked River elevation is about 1,100 feet mean sea level (M.S.L.) at the headwaters and 675 feet M.S.L. at the mouth.

The Crooked River basin is located 30 miles east of Kansas City, Missouri and covers portions of Caldwell, Clay, Clinton and Ray counties. The population in the basin is expanding as Kansas City suburbs expand eastward into the upper reaches of the watershed (MDNR 1995). The population of Ray County in 1990 was 21,971 (Census Bureau Website). This would probably be a slight overestimation of the Crooked River basin population. Several small communities are found partially or entirely within the basin including Elmira, Hardin, Henrietta, Lawson, Polo and Rayville. The largest city in the basin is Richmond (population 5,738; 1990 U.S. Census).

The Crooked River basin is assigned watershed number 140 within the lower Missouri River basin (hydrologic code 10300101; USDA-SCS 1990). With the Crooked River basin being considered a watershed within a larger basin, statistics are hard to find that are broken down to the watershed level. Some important information specifically for the Crooked River basin was not available. Most of the Crooked River basin is in Ray County, Missouri, so where information for the basin is lacking, estimates were based on Ray County statistics and noted in the text. Every effort was made to present the best estimates and most comprehensive information that could be obtained.

Figure 1. Crooked River watershed.



Geology

Physiographic Region

The majority of the Crooked River basin lies within the Western Glaciated Plains Natural Division with a small area near the mouth in the Big Rivers Upper Missouri Natural Division (Figure nd)(Thom and Wilson 1980). The entire basin is in the Dissected Till Plains and is near the southern edge of the area covered by glaciers (Detroy and Skelton 1983). The basin topography consists of rolling to hilly glacial plains with narrow ridges and steep side slopes. The Missouri River flood plain near the mouth of the Crooked River is extremely flat and poorly drained.

Geology and Soils

The basin is underlain by Pennsylvanian-aged formations consisting primarily of sandstone, shale, limestone and thin seams of coal (Figure ge)(Detroy and Skelton 1983). The bedrock slopes from the southwest to the northeast underneath the basin. Large areas of Bethany limestone are found in the western part of the basin (Preston 1986). The lower Crooked River basin is underlain by the Lexington coal field (MDNR 1986a).

Most basin soils are formed from glacial till (a mixture of clay, rock, gravel and sand), alluvium (water deposited soil) and a windblown silt called loess. The soils have their origin in the four periods of continental glaciation with deposits from the final glacial advance (Kansan) overlying earlier deposits. After glaciation a thick layer of loess was deposited over the basin creating a relatively level drift plain (USDA-SCS 1982). Weathering over several thousand years has produced dissected glacial till plains overlain by loessial soils. Loess deposits decrease in thickness from southwest to northeast across the basin. (Preston 1986). Loess deposits range from 32 feet deep near the Missouri River to about eight feet deep near the headwaters (MDNR 1995). Loessial soils cover broad, gently sloping ridges of silty loam and are suitable for farming. Glacial soil occurs on steeper, eroding slopes and it is a less productive brown loam or gritty silt loam. Glacial deposits overlie limestones and shales and are generally less than 100 feet thick (MDNR 1995). Valleys are covered with alluvial silt and clay loams, and are the most productive soils in the basin. Areas where surface soil has been eroded and subsoil has been exposed are less productive (USDA-SCS 1982).

Watershed Area

The Crooked River is a sixth order river with a basin area of 335 square miles (214,790 acres; USDA-SCS 1982). The Crooked River basin is bordered by the Fishing River basin to the west, the

Wakenda River basin and Moss Creek to the east (all minor Missouri River tributaries) and the Grand River basin to the north. The basin has a maximum width of about 20 miles. The flood plain width varies from 500 feet in the upper reaches to about one mile in lower sections of the basin (NRCS field exam report). The Crooked River mainstem is about 70 miles in length and runs from northwest to southeast.

Channel Gradient

Channel gradients for most of the Crooked River watershed were reported to range from 5 to 50 feet per mile in 1976. The gradients found in the Missouri River bottom area were about 1/2 foot per mile (NRCS field exam report). Based on current topographical maps, average gradients in the Crooked River basin range from 5 to 138 feet per mile. Stream gradient information for fourth order and larger streams in the Crooked River basin can be found in Appendix A.

Figure nd. Location of the crooked River watershed in the natural divisions of Missouri.

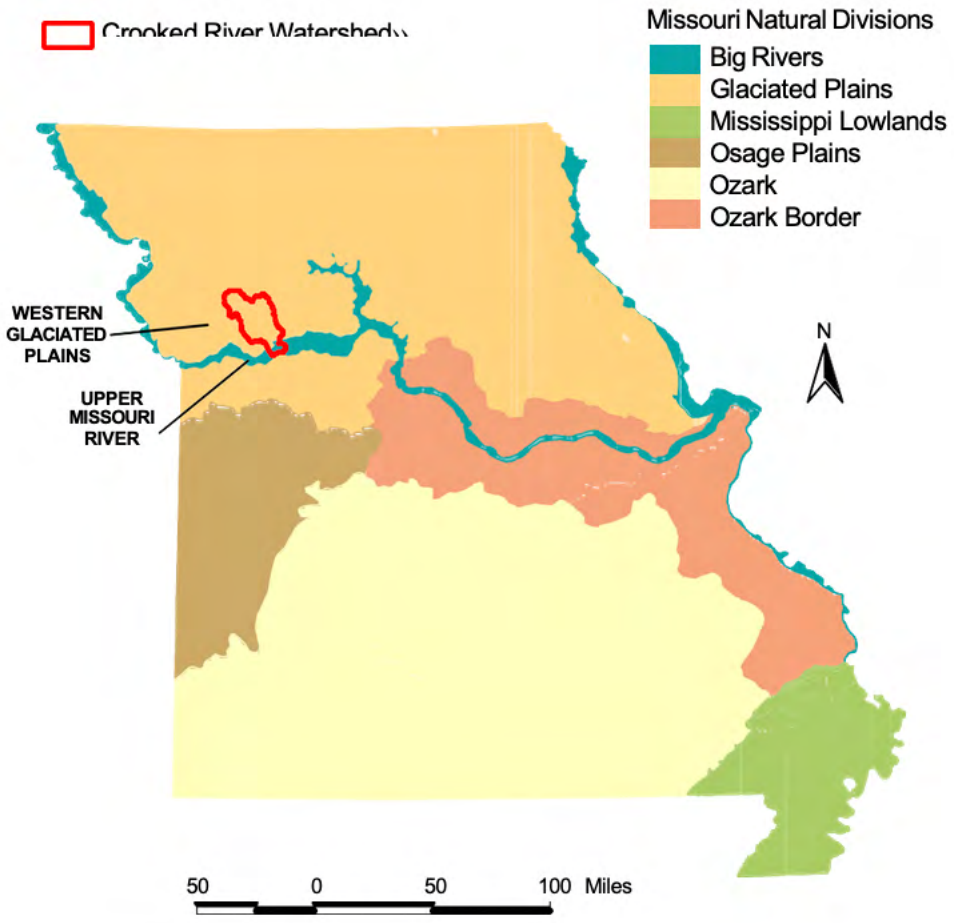
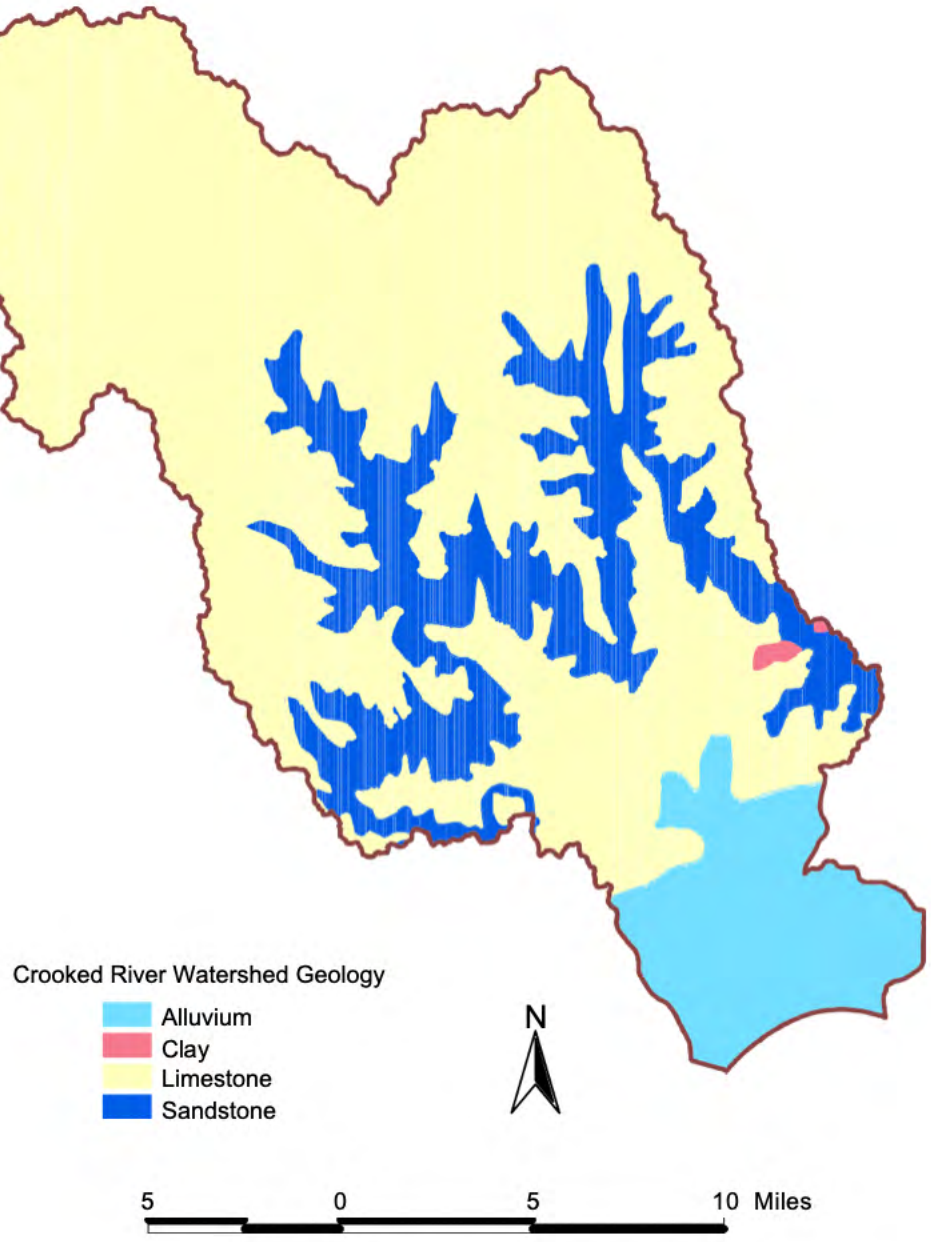
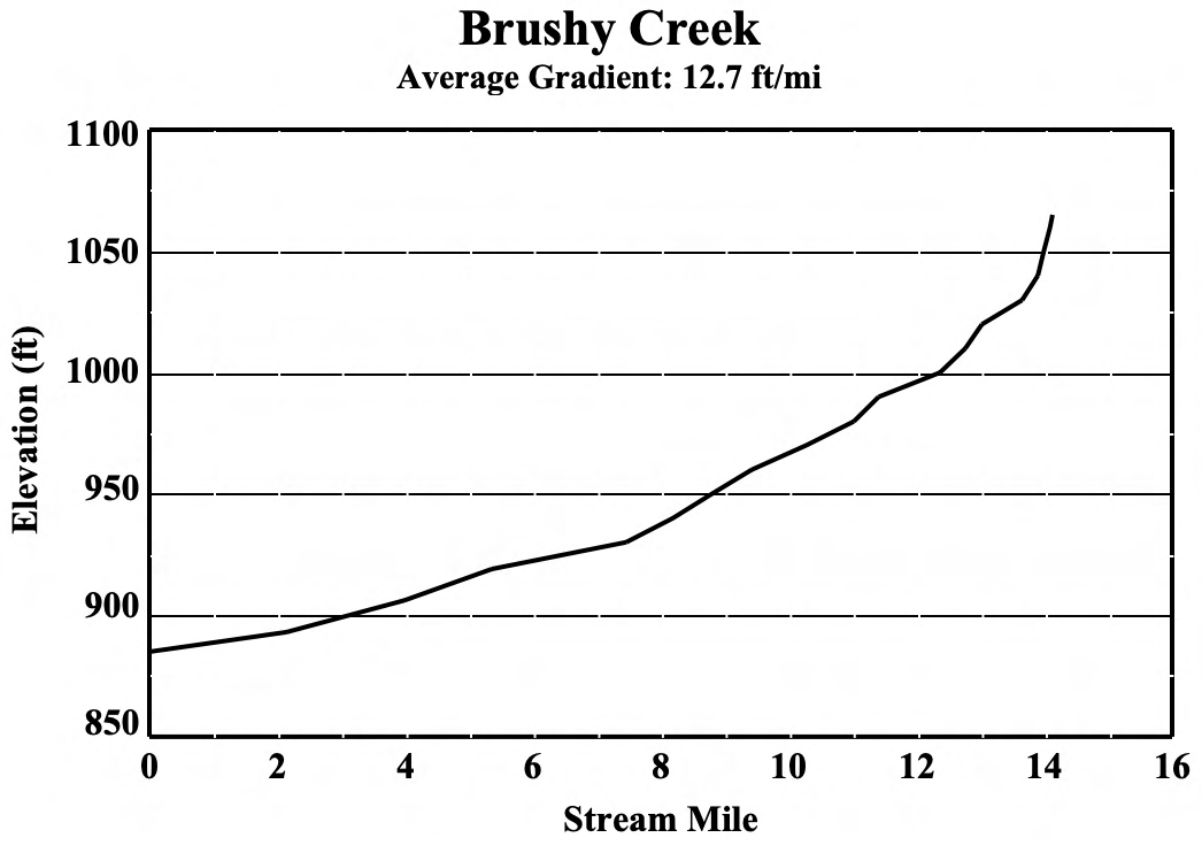


Figure ge. Geology in the Crooked River watershed.

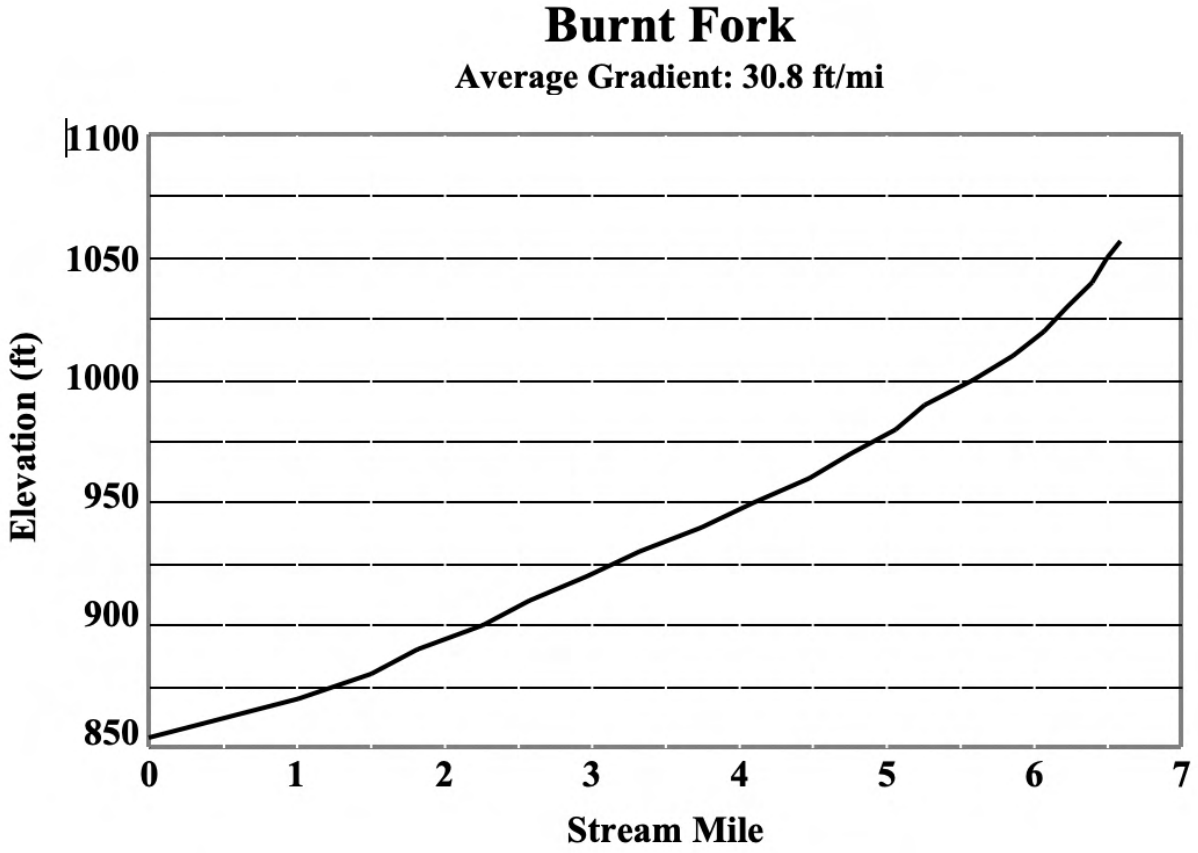


Appendix A. Gradient plots of fourth order and larger streams within the Crooked River basin, digitized from 7.5 minute series, 1:24,000 scale, USGS topographic maps. Gradient plots are organized by stream proximity to mouth of the Crooked River.

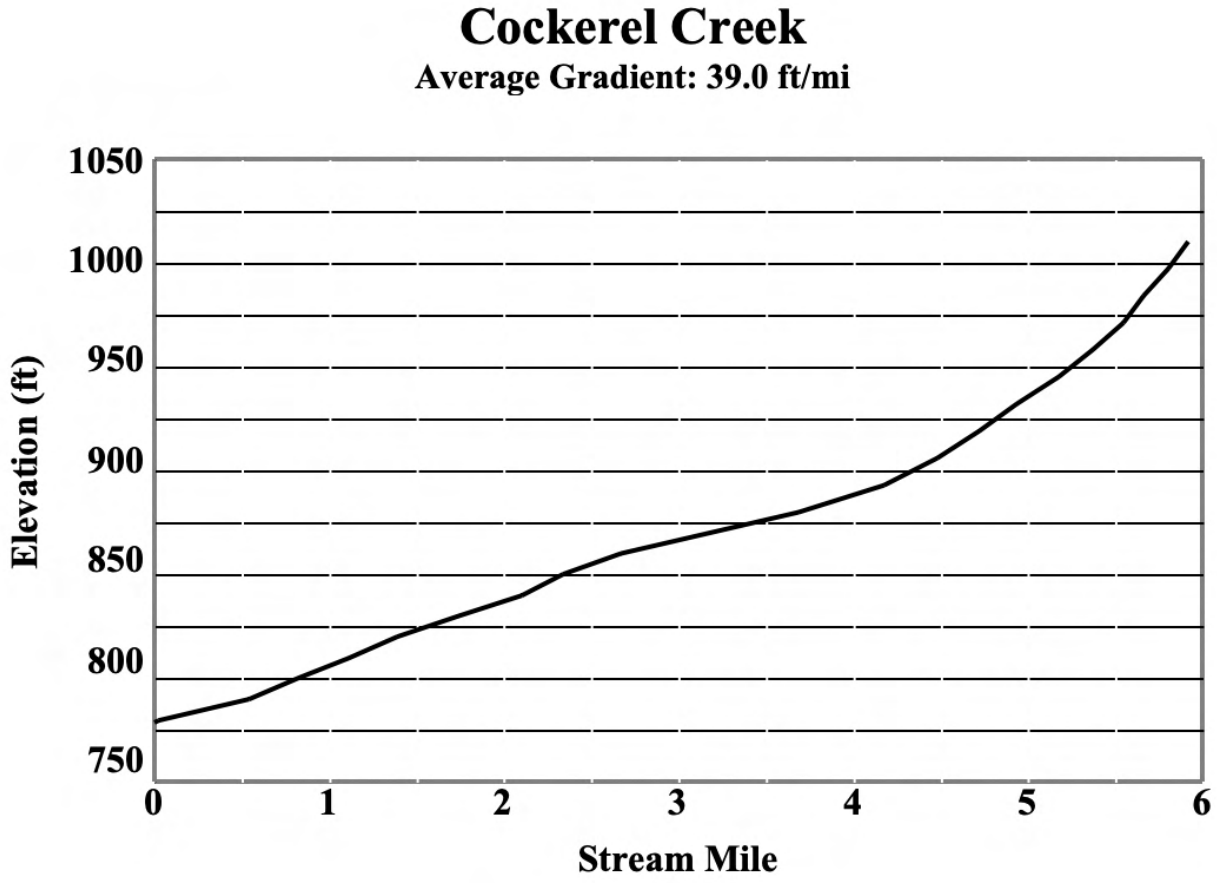
Appendix A. Gradient plot for Brushy Creek, a 4th order tributary of the Crooked River in the Crooked River watershed. The location of the mouth is at Township 55, Range 29 and Section 33. The stream is located on 7.5 minute quadrangle maps Elmira and Lawson.



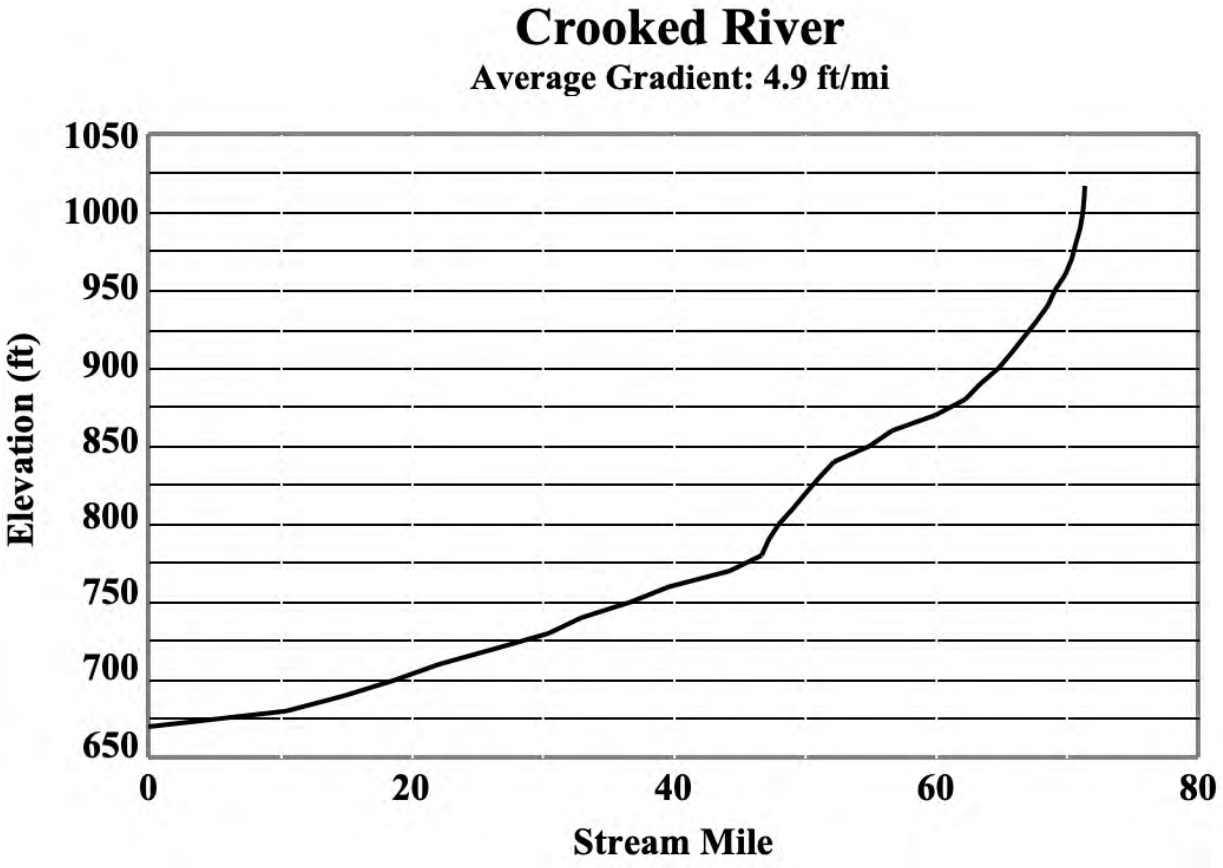
Appendix A. Gradient plot for Burnt Fork, a 4th order tributary of the Crooked River in the Crooked River watershed. The location of the mouth is at Township 54, Range 29 and Section 09. The stream is located on 7.5 minute quadrangle maps Elmira and Lawson.



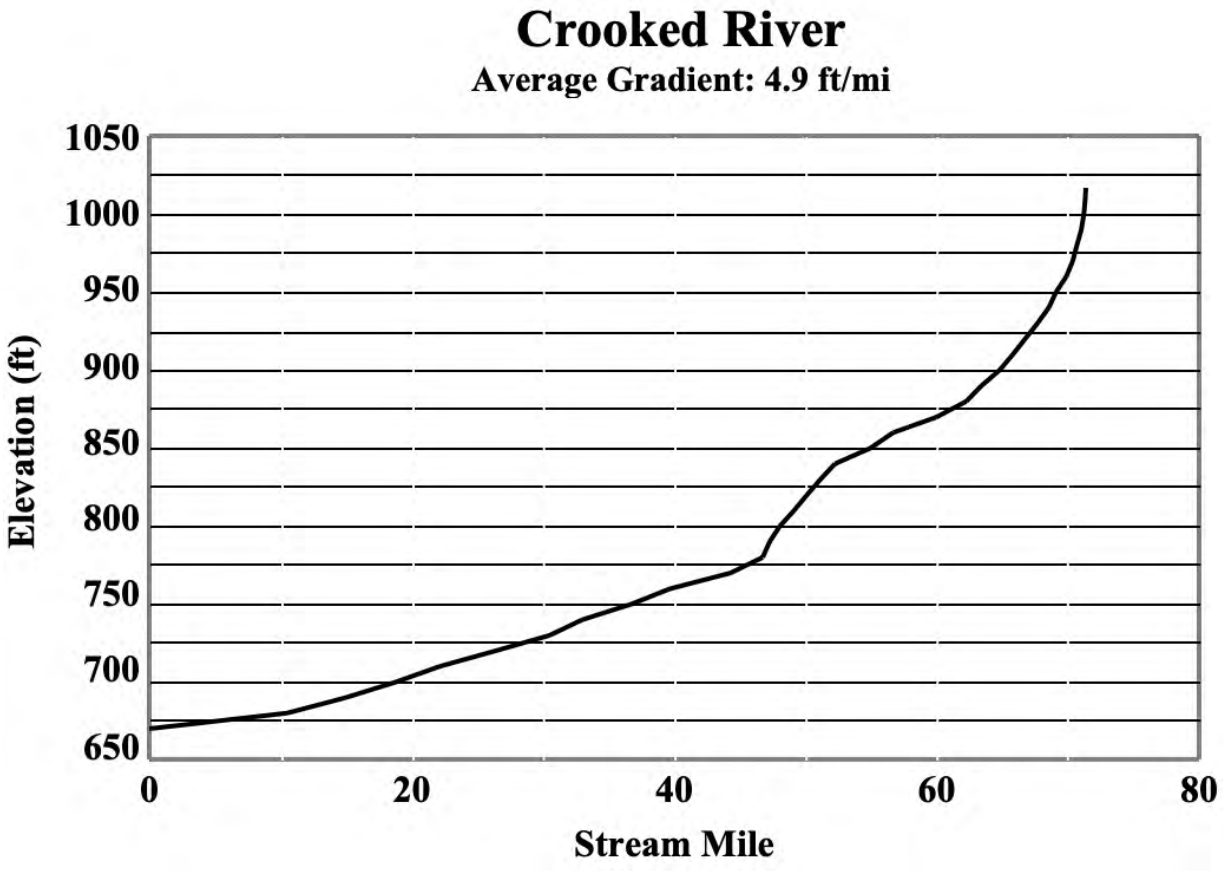
Appendix A. Gradient plot for Cockerel Creek, a 4th order tributary of the Crooked River in the Crooked River watershed. The location of the mouth is at Township 54, Range 28 and Section 19. The stream is located on 7.5 minute quadrangle maps Knoxville and Polo.



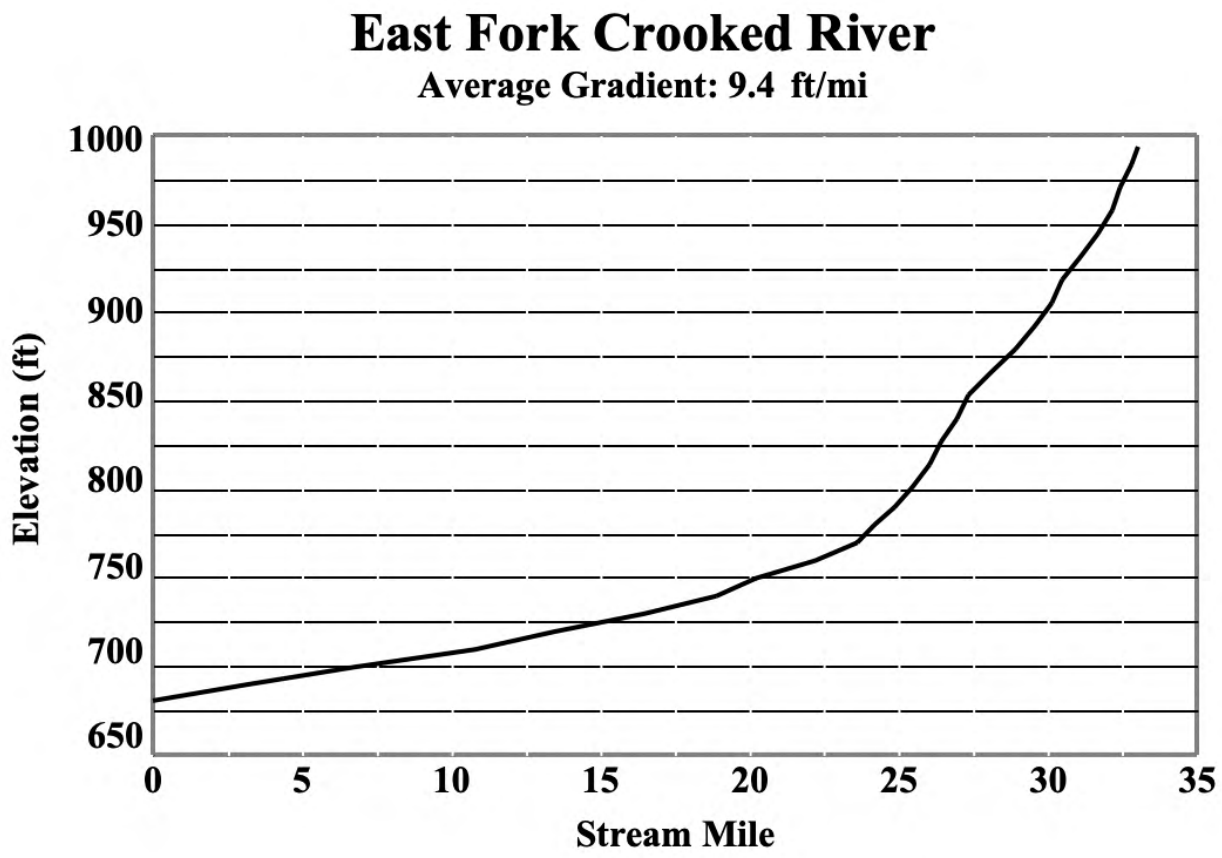
Appendix A. Gradient plot for Crooked River, the 6th order main channel in the Crooked River watershed. The location of the mouth is at Township 51, Range 26 and Section 14. The stream is located on 7.5 minute quadrangle maps Lexington, Hardin, Richmond, Rayville, Knoxville, Lawson, Elmira, and Lathrop.



Appendix A. Gradient plot for East Fork Crooked River, a 5th order tributary of the Crooked River in the Crooked River watershed. The location of the mouth is at Township 52, Range 27 and Section 23. The stream is located on 7.5 minute quadrangle maps Richmond, Millville, and Cowgill.

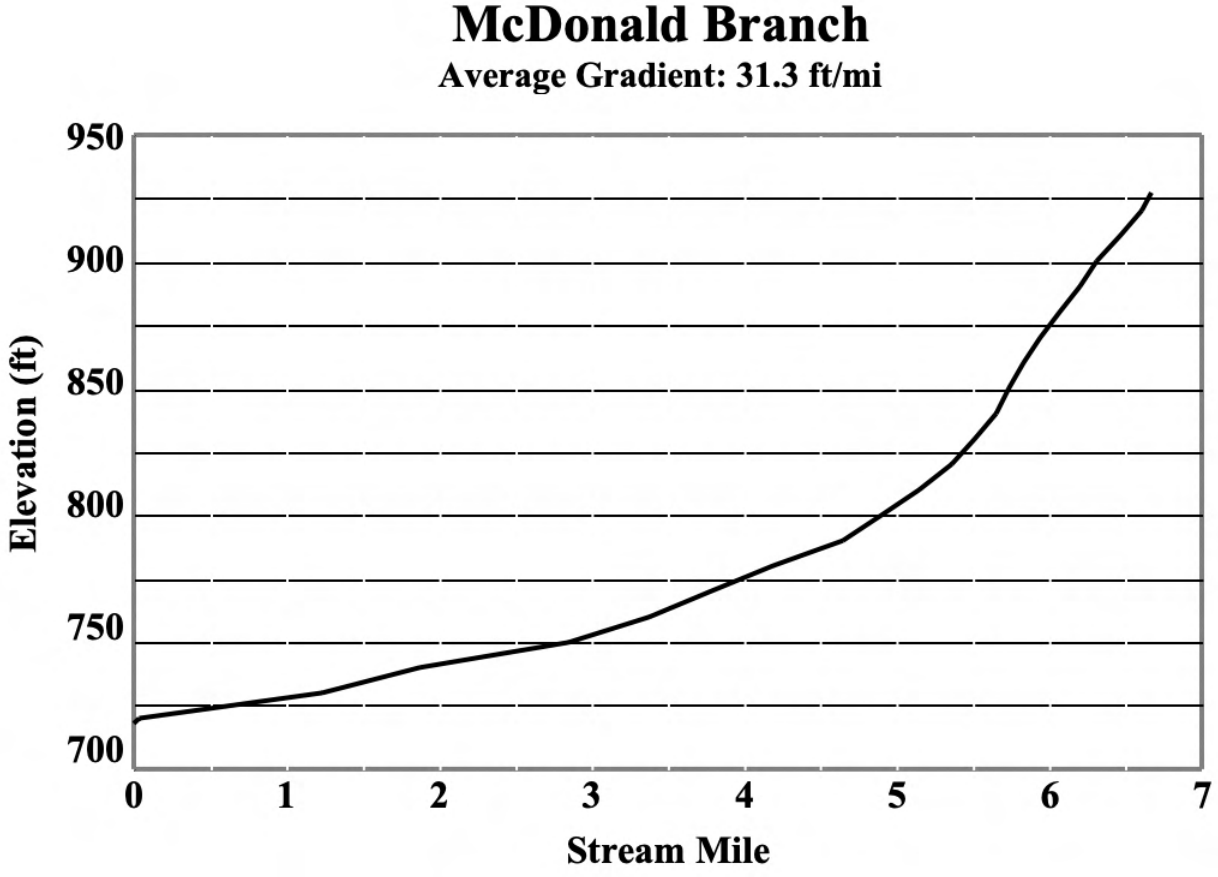


Appendix A. Gradient plot for East Fork Crooked River, a 5th order tributary of the Crooked River in the Crooked River watershed. The location of the mouth is at Township 52, Range 27 and Section 23. The stream is located on 7.5 minute quadrangle maps Richmond, Millville, and Cowgill.

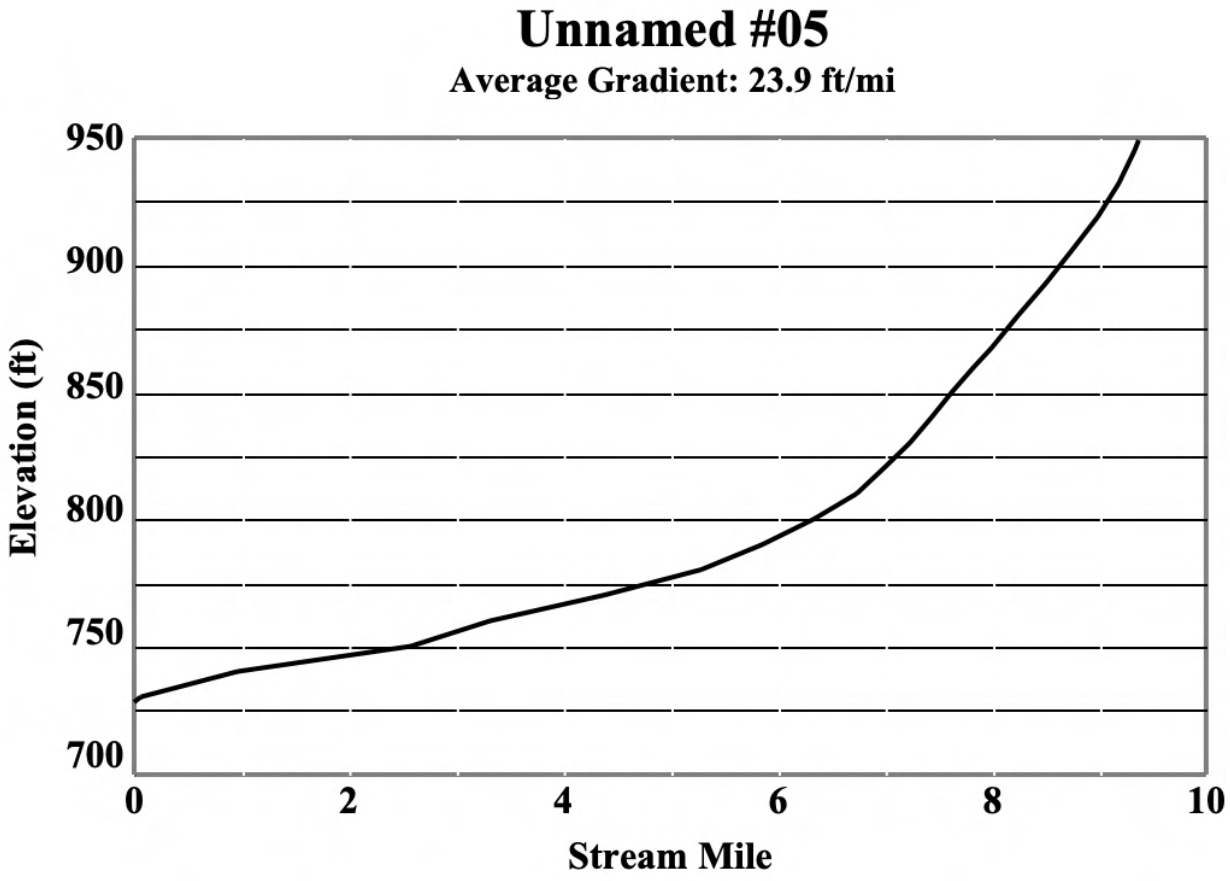


Appendix A. Gradient plot for McDonald Branch, a 4th order tributary of the Crooked River in the Crooked River watershed. The location of the mouth is at Township 53, Range 28 and Section

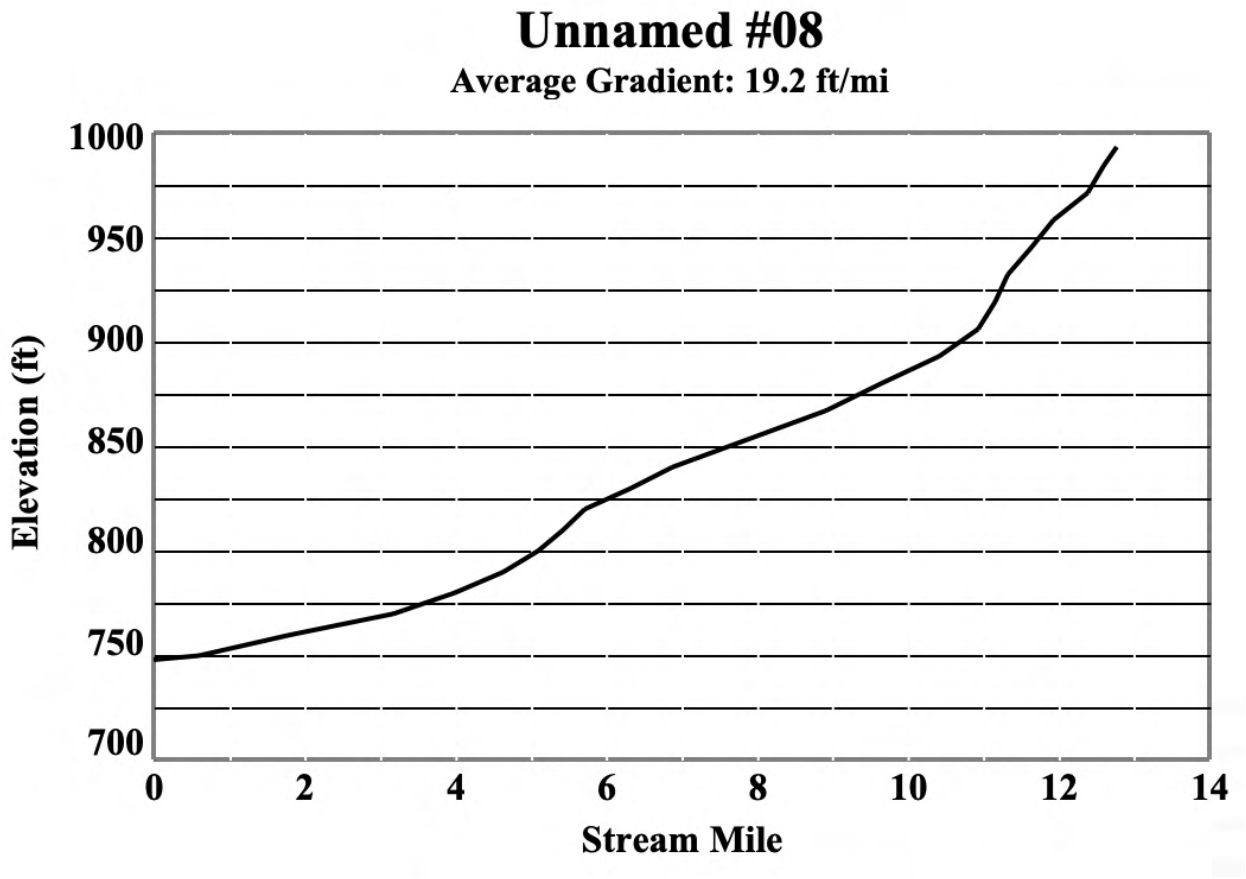
36. The stream is located on 7.5 minute quadrangle maps Richmond, Rayville, and Knoxville.



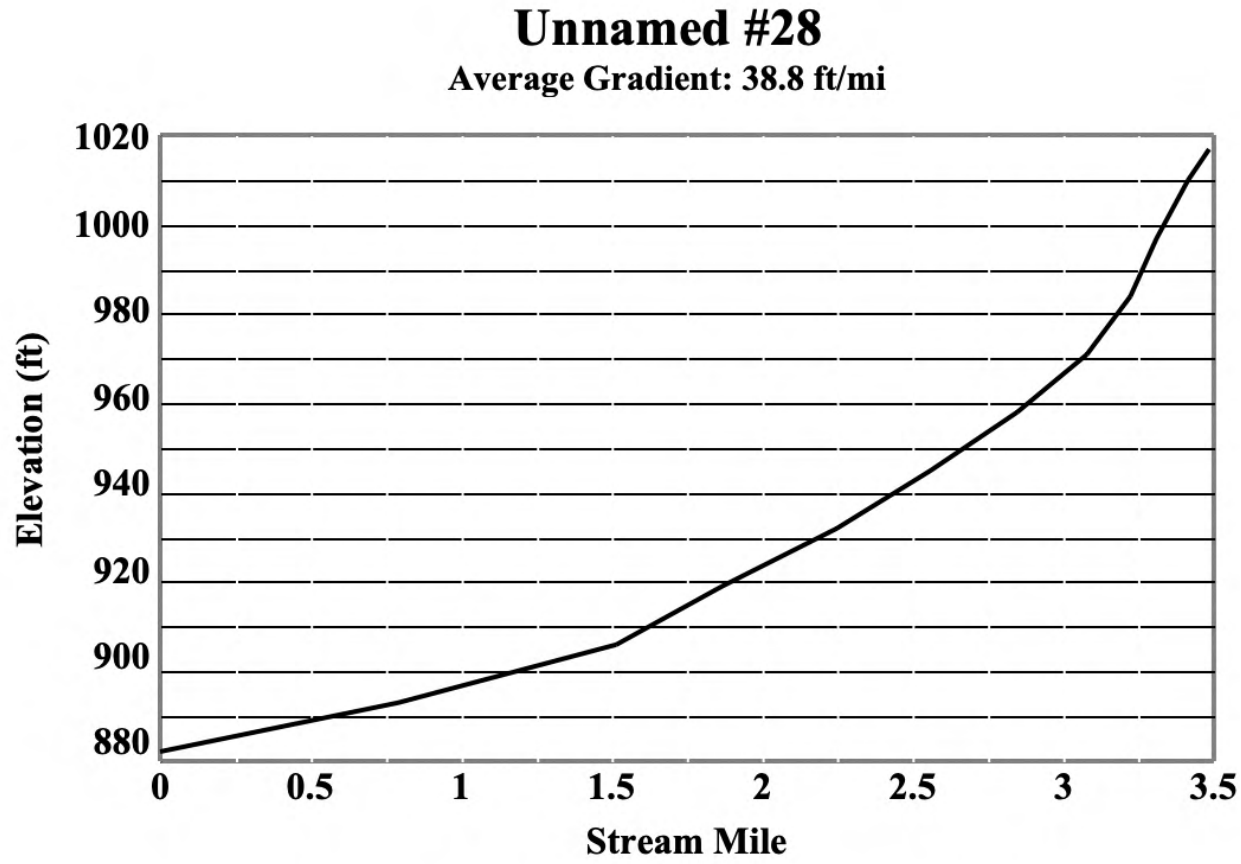
Appendix A. Gradient plot for Unnamed #05, a 4th order tributary of the East Fork Crooked River in the Crooked River watershed. The location of the mouth is at Township 53, Range 27 and Section 09. The stream is located on 7.5 minute quadrangle maps Millville and Cowgill



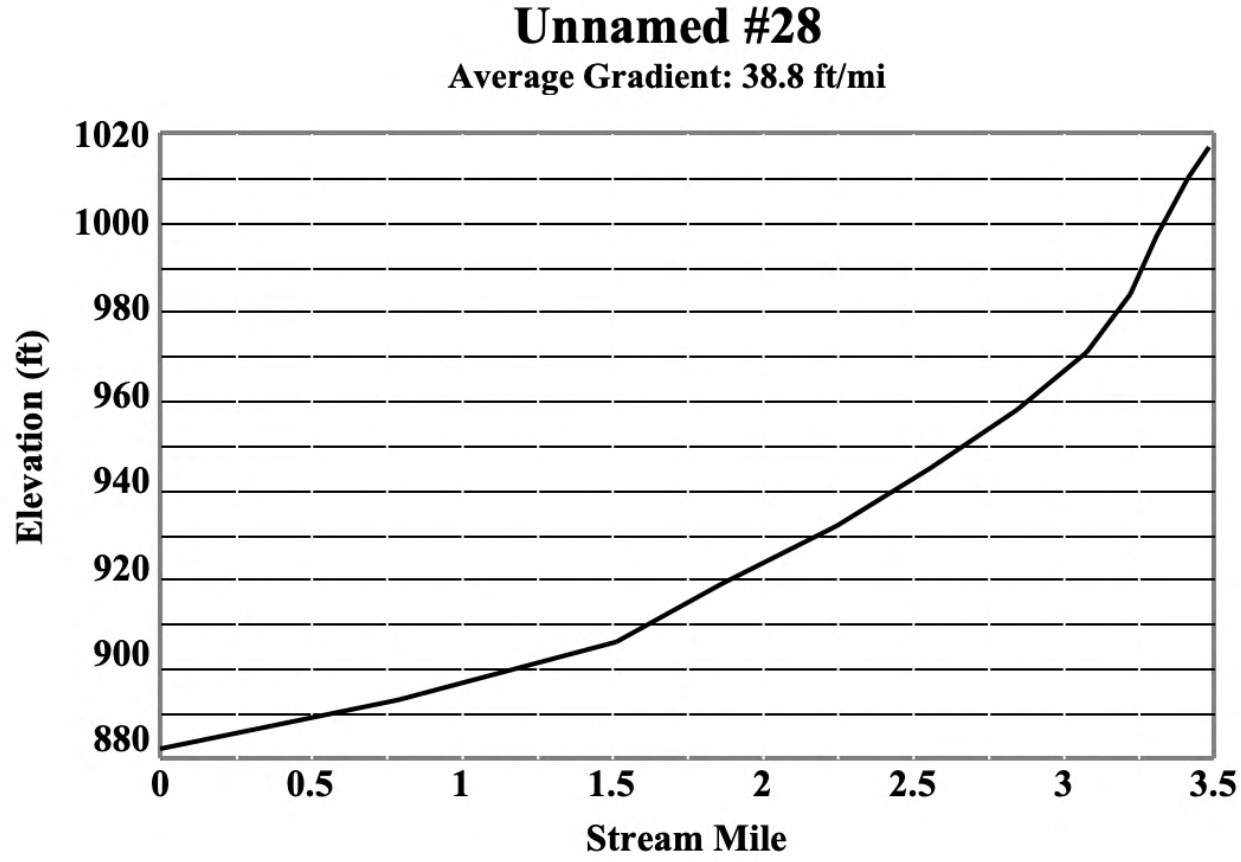
Appendix A. Gradient plot for Unnamed #08, a 4th order tributary of the East Fork Crooked River in the Crooked River watershed. The location of the mouth is at Township 54, Range 27 and Section 29. The stream is located on 7.5 minute quadrangle maps Millville, Knoxville, and Polo.



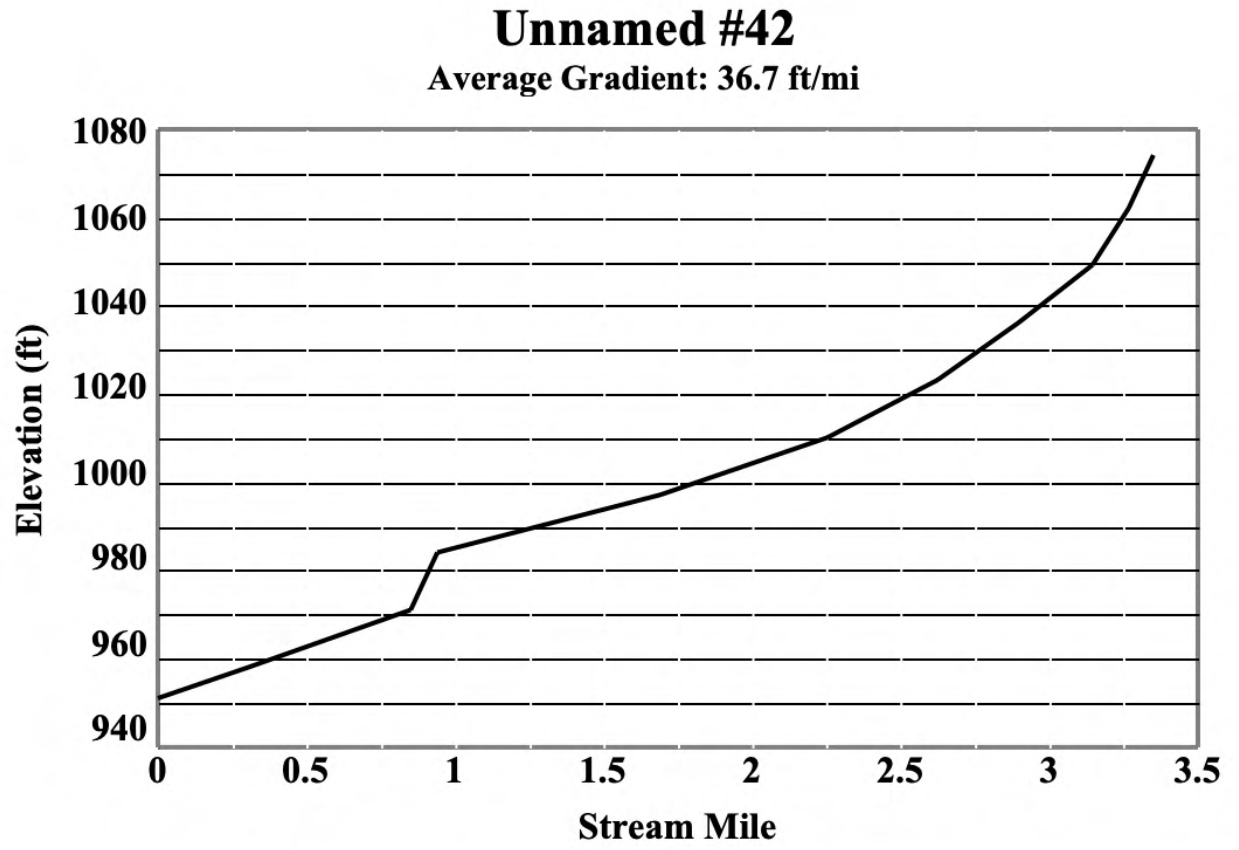
Appendix A. Gradient plot for Unnamed #28, a 4th order tributary of the Crooked River in the Crooked River watershed. The location of the mouth is at Township 55, Range 29 and Section 33. The stream is located on 7.5 minute quadrangle map Elmira.



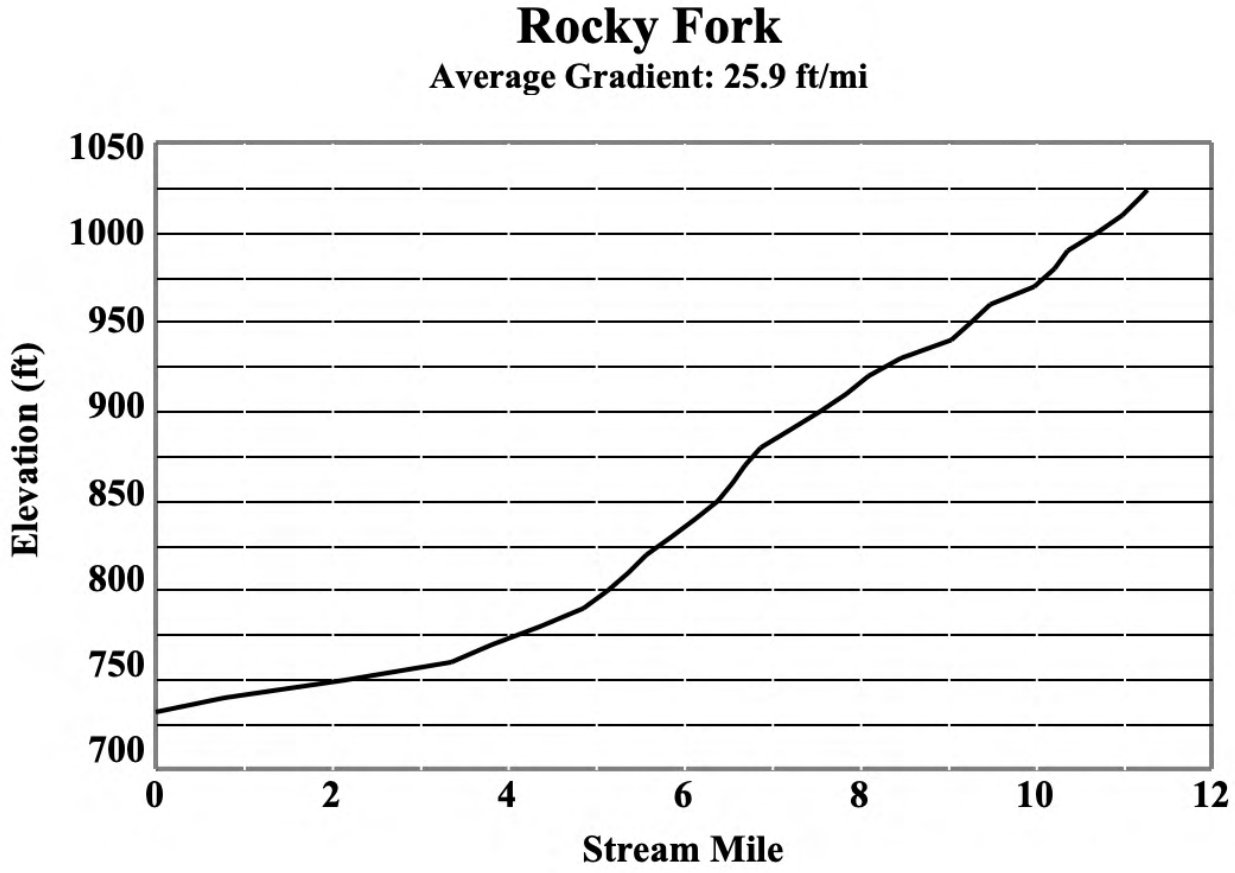
Appendix A. Gradient plot for Unnamed #32, a 4th order tributary of Brushy Creek in the Crooked River watershed. The location of the mouth is at Township 54, Range 29 and Section 18. The stream is located on 7.5 minute quadrangle maps Lawson, Elmira, and Lathrop.



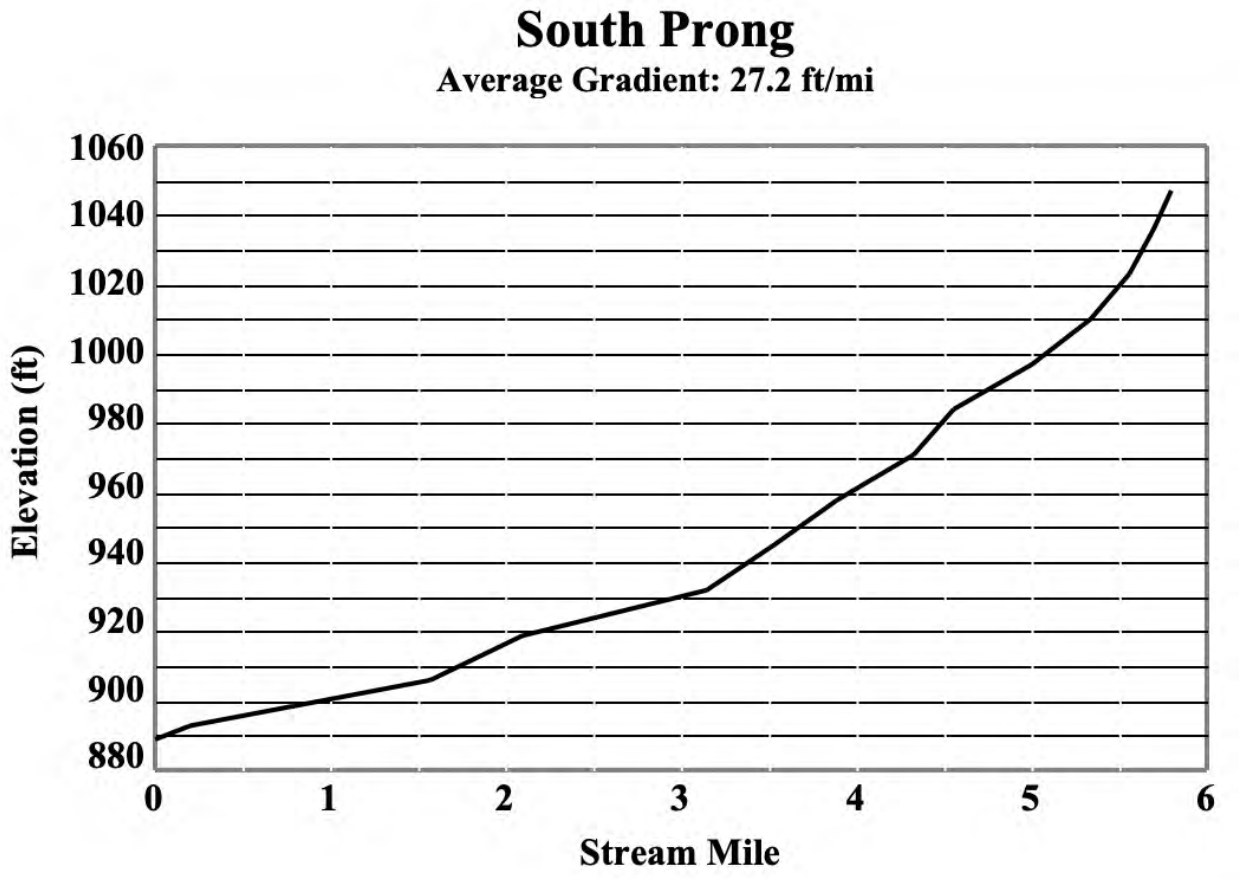
Appendix A. Gradient plot for Unnamed #42, a 4th order tributary of the Crooked River in the Crooked River watershed. The location of the mouth is at Township 55, Range 30 and Section 35. The stream is located on 7.5 minute quadrangle maps Elmira and Lathrop.



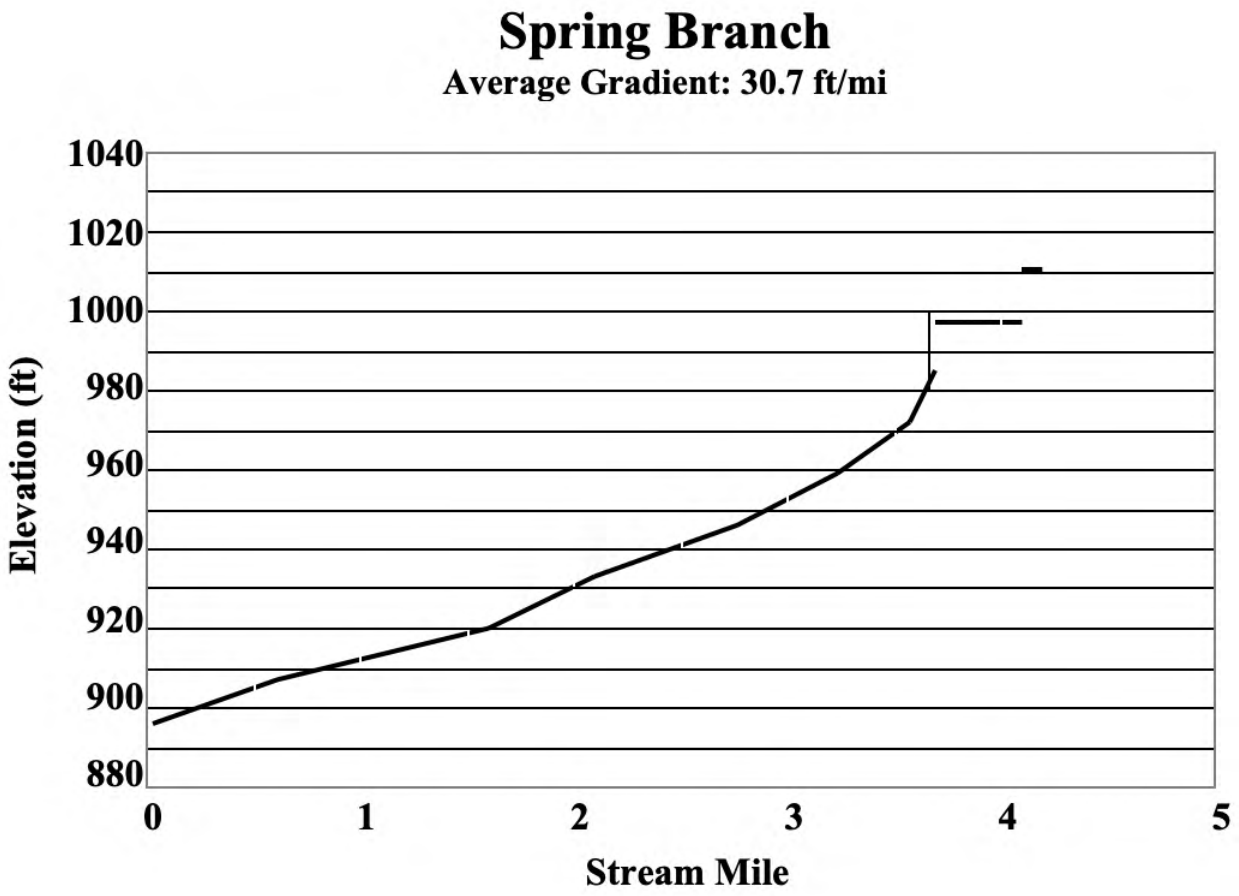
Appendix A. Gradient plot for Rocky Fork, a 4th order tributary of the Crooked River in the Crooked River watershed. The location of the mouth is at Township 53, Range 28 and Section 28. The stream is located on 7.5 minute quadrangle maps Rayville, Knoxville, and Lawson.



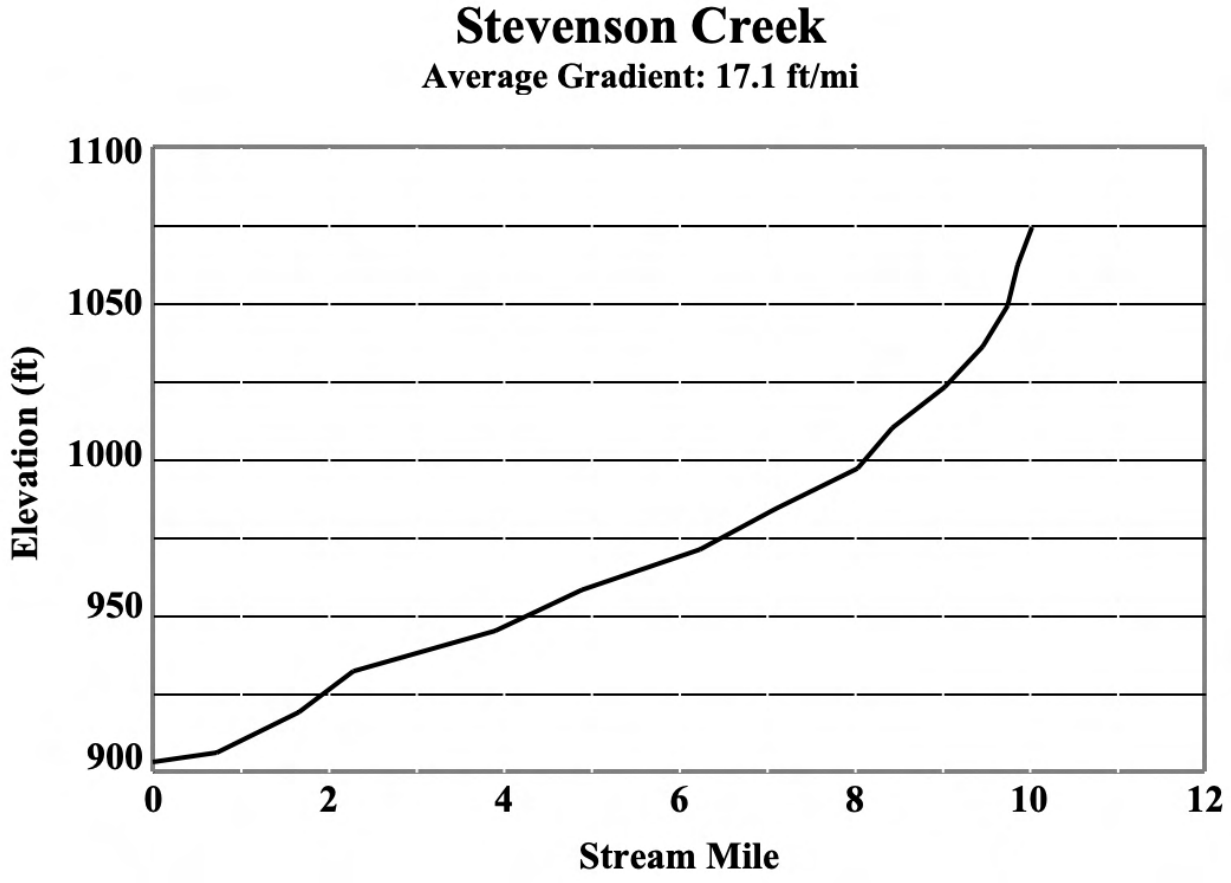
Appendix A. Gradient plot for South Prong, a 4th order tributary of the Crooked River in the Crooked River watershed. The location of the mouth is at Township 55, Range 29 and Section 28. The stream is located on 7.5 minute quadrangle map Elmira.



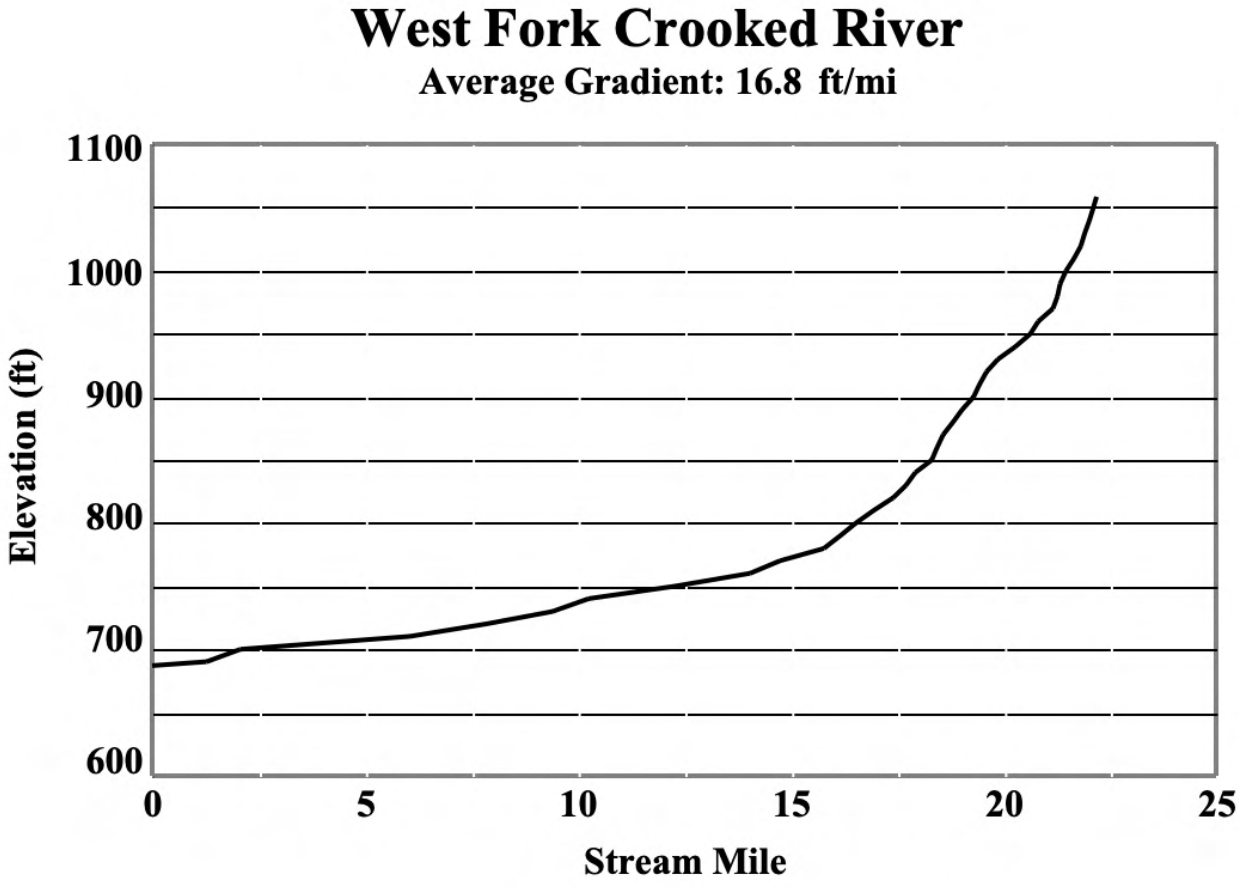
Appendix A. Gradient plot for Spring Branch, a 4th order tributary of the Crooked River in the Crooked River watershed. The location of the mouth is at Township 55, Range 29 and Section 29. The stream is located on 7.5 minute quadrangle map Elmira.



Appendix A. Gradient plot for Stevenson Creek, a 4th order tributary of the Crooked River in the Crooked River watershed. The location of the mouth is at Township 55, Range 29 and Section 29. The stream is located on 7.5 minute quadrangle maps Elmira and Lathrop.



Appendix A. Gradient plot for West Fork Crooked River, a 4th order tributary of the Crooked River in the Crooked River watershed. The location of the mouth is at Township 52, Range 27 and Section 27. The stream is located on 7.5 minute quadrangle maps Richmond, Rayville, and Excelsior.



Land Use

Historic and Recent Land Use

The area including the Crooked River basin has been frequented by people for thousands of years based on archeological records. French and Spanish explorers were in the area as early as the 1500's. The first settlers reportedly arrived from Tennessee in 1815 and lived at what they called "Buffalo" which would be near present day Hardin, Missouri. Most of the early settlers were from Tennessee, Kentucky and Virginia. The Indians inhabiting the area at this time were primarily Sac and Iowa, although Osage Indians were occasionally encountered. Ray County (included the area that is currently divided into Carroll, Clay, Clinton, Dekalb, Gentry, Grundy, Harrison, Mercer, Ray and Worth counties) came into being as an officially recognized part of Missouri in 1821 (Ray County History 1881). The county seat was originally Bluffton (near present day Camden), but was relocated to Richmond in 1828. Ray County as well as Caldwell, Clinton and Clay counties, were assigned their current configuration in 1836. The area was subject to troop movements, skirmishes, battles, and raids during, and for a brief period after, the Civil War (Preston 1986).

In the 1800's, flora and fauna were reportedly diverse and abundant. Along the streams and rivers, forests were dense and varied with species including oaks, elms, hickory, pecan, black walnut, maples, linden, cottonwood and others. The hilltops and ridges were for the most part timbered. Areas of prairie were interspersed between wooded areas. Estimates indicate about 35% of the Crooked River basin was historically prairie (Schroeder 1982). In the 1980's, the upland forests were of the oak-hickory type with white oak, black oak, northern red oak, hickory, white ash, winged elm, hackberry and post oak being the most commonly encountered species. Flood plain forests were narrow corridors restricted to creek and river margins, consisting primarily of cottonwood, green ash, silver maple, box elder, elms and hackberry. In the early 1980's, forest covered only ten percent of Ray County and was decreasing (Preston 1986).

Wildlife reported to be found in Ray County in the 1800's included "panther, bear, jackal, lynx, wildcat, catamount, wolf, fox, turkey, bison, elk, deer, bobwhite quail, prairie chicken, ducks, geese, snipe, plover, rail, fox squirrel, grey squirrel and rabbit" (History of Ray County 1881). Large quantities of meat from game animals (specifically mentioned were deer and barrels of prairie chickens) were sent to St. Louis and from there to the eastern markets from this area (History of Ray County 1881). The fishes reported from the area were "black bass, perch, catfish, buffalo fish, suckers, and pike" (History of Ray County 1881). Fishing in the streams was conducted from a canoe using wooden torches and gigs at night. The water was considered clear and the fish numerous (History of Ray County 1881).

Early agricultural activities were confined to the fertile valleys and Missouri River flood plain (mentioned as being about 5 miles wide) which was considered to have good natural drainage favorable to cultivation. Floods occurred in June 1827, June 1844, and April 1881 but were considered to be infrequent and not a problem (History of Ray County 1881). In 1979, 125,500 acres were cultivated in Ray County for soybean and corn production (Preston 1986).

Land use estimates for the Crooked River basin (based on Missouri River basin statistics) is 42% cropland, 25% grassland, 21% urban, and 12% forest lands (Missouri Resource Assessment Partnership [MoRAP] phase 2 landcover map - Figure lu). These percentages are probably higher for agriculture/forest and lower for urban in the Crooked River basin as Kansas City is figured into the Missouri River basin statistics. In 1998, the basin remains predominantly rural and agriculturally oriented, but encroachment of urban sprawl from the Kansas City metro area is beginning to impact the western edge. Future threats are probably going to be urbanization and development in the western areas of the basin, increased agricultural row crops on marginal farmland, and concentrated animal feeding operations.

Soil Conservation Projects

The Ray County Soil and Water Conservation District (SWCD) was formed in 1945 (Preston 1986). There are several conservation programs, both state and federally sponsored, that provide technical and/or financial assistance to land owners in the basin.

Two of the available programs are Special Area Land Treatment (SALT) and EARTH projects, sponsored by the Missouri Department of Natural Resources (MDNR). These programs are coordinated through local Soil and Water Conservation Districts and make resources available for land owners in each target watershed. There are no EARTH projects in the basin at this time.

SALT projects focus on particular watersheds, and through landowner cooperation strive to improve soil conservation. The SALT programs use total resource management planning to treat land so that all resources are used effectively, while being protected from excessive soil erosion. Other goals of the program include: improved water quality and reduced sedimentation, increased use of conservation oriented agricultural practices, improved grassland establishment, better management of animal waste, increased timberland productivity, and improved wildlife habitat. The only completed SALT project in the basin is Little Muddy, and it was active from 1986 through 1993 (NRCS personal communication). Soil conservation practices used were steep back terraces, diversions, broad base terraces and waterways. The erosion has dropped from over twenty tons per acre per year to 5 tons per acre per year in the Little Muddy SALT area (MU Agronomy Technical report vol. 7 no. 6).

The USDA has worked with farmers to enhance soil conservation with their Conservation Reserve Program (CRP). This program was enacted Dec. 23, 1985 as part of the Food Security Act of 1985, in an effort to reduce crop farming on highly erodible cropland. It encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover such as native grasses, wildlife plantings, trees, filterstrips, or riparian buffers. Bids are ranked according to the National Environmental Benefits Index which has seven ranking factors. These include: wildlife habitat, water quality, erosion reduction, long-term retention (primarily based on trees), air quality, conservation priority area, and cost. Farmers receive an annual rental payment for the term of the multi-year contract (usually 10 years). Cost sharing is provided to establish the vegetative cover practices. The program has been extended several times since the original contracts expired in 1996. Some land has reverted and some new land has been enrolled with each new contract period. In the Crooked River basin the cropland acreage enrolled has remained at approximately 21,000 acres from 1997 through 1999 (J. Rehmsmeyer, NRCS pers. comm.).

Another source of aid for watershed projects is the Public Law 83-566 (PL-566) program. These partnerships require local and state funding contributions in addition to federal resources. Watershed projects that can qualify under this program may include those whose purpose are: watershed protection, flood prevention, water quality improvements, soil erosion reduction, water supply, irrigation water management, sedimentation control, fish and wildlife habitat enhancement and creation/restoration of wetlands and wetland functions. These projects can be large in scale with congressional committee approval required only on projects where federal funding expenditures exceed five million dollars for construction, or construction of a single structure with a capacity in excess of 2,500 acre feet. As of 1998 there are over 1,600 of these projects in operation nationwide. The entire Crooked River basin is an approved PL-566 watershed project (active approved application for 214,790 acres). However, active operations are not occurring at this time (1998) and local NRCS officials do not predict any activity for the near future (J. Rehmsmeyer, NRCS, personal communication).

Cropland acreage is increasing in the Crooked River basin and pasture acreage is decreasing. Pasture is steadily being converted to row crops. The major row crops are soybeans and corn. Wheat is sometimes double cropped with soybeans. Wheat and grain sorghums are minor agricultural row crops (Preston 1986).

Public Areas

There are 2,182 acres (1% of watershed total) of public land in the Crooked River basin. Table 1 contains specific information for public areas in the basin. Figure 2 shows the location of public lands within the basin. With the exception of the boat ramp west of Hardin (managed by Hardin Special Road District), all of the Crooked River basin public lands (2,182 acres; Table 1) are managed by the Missouri Department of Conservation (MDC). Areas range from fishing lakes to moderately managed upland and natural areas with both consumptive and non-consumptive uses.

There are 5 stream access sites in the basin. The four sites located above the East Fork Crooked River and Crooked River confluence on the mainstem Crooked River offer bank fishing and non-improved boat access. A small area on the lower Crooked River just west of Hardin has a concrete boat ramp and dirt parking lot. An area along the upper Crooked River near Elmira (T54N, R29W, sec 3 to T54N, R29W, sec 13) was rated as a high priority area for frontage acquisition by MDC to preserve remnant or high quality habitat and provide both bank and wade fishing access (McPherson 1994).

Within the basin there are 2 public fishing impoundments, Ray County Community Lake and Lawson City Lake (Table 1). The lakes are both about 25 acres in size, have boat ramps and are disabled user accessible. Ryck (1991) lists Crooked River Conservation Area (CA) as a low priority for lake and pond construction. The northeast corner of the Crooked River basin (headwaters area of the East Fork Crooked River) is a potential small public lake acquisition area (Ryck 1991).

Corps of Engineers Jurisdiction

Most instream and some stream-side projects require 404 permits. Applications for permits should be directed to the U.S. Army Corps of Engineers office. The Crooked River basin in Missouri is under the jurisdiction of the Kansas City District.

Kansas City District COE

700 Federal Building

Kansas City, MO 64106-2896

(816)426-5357

Figure lu. Land use/land cover within the Crooked River basin (MORAP 1999, preliminary data).

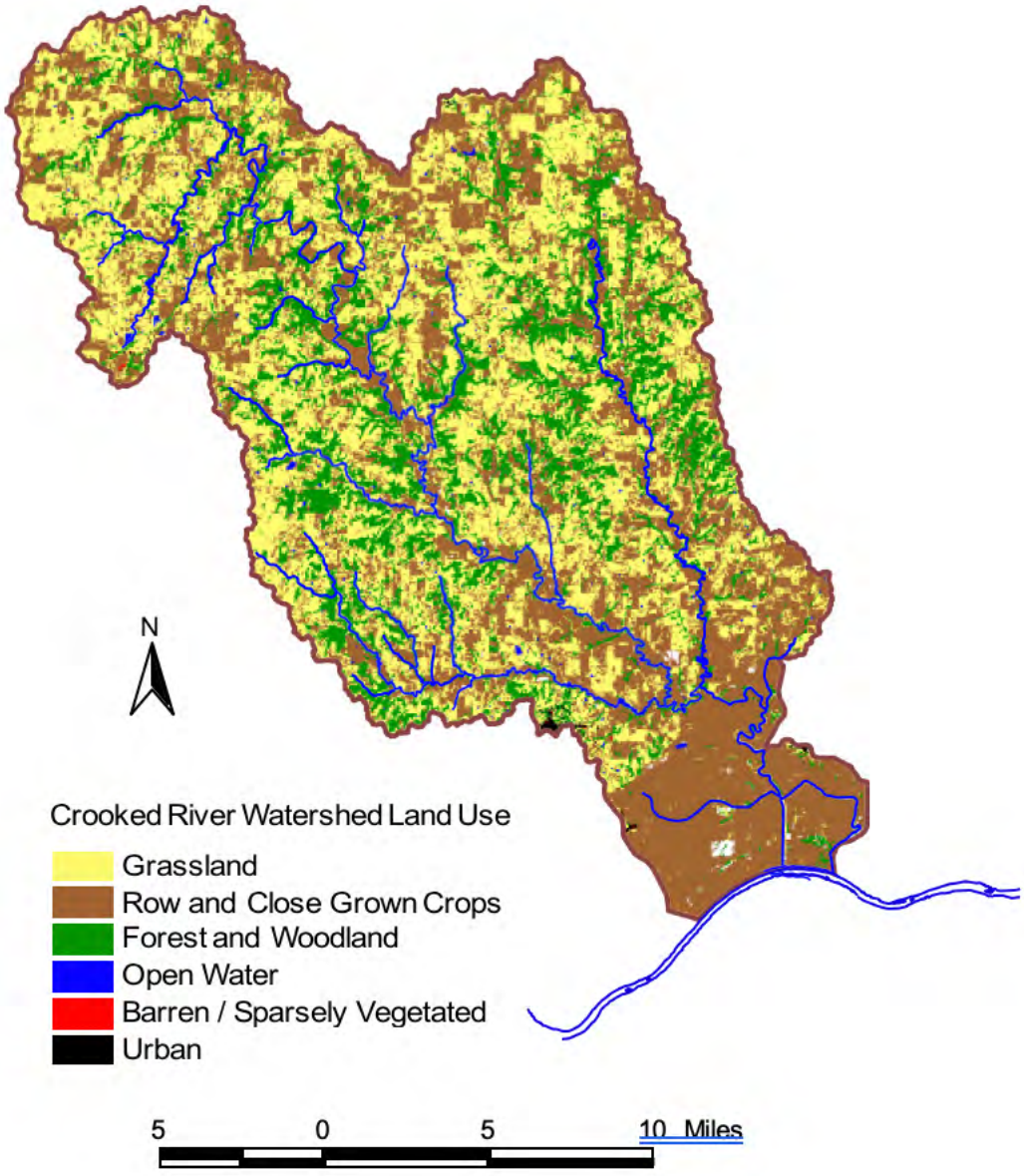
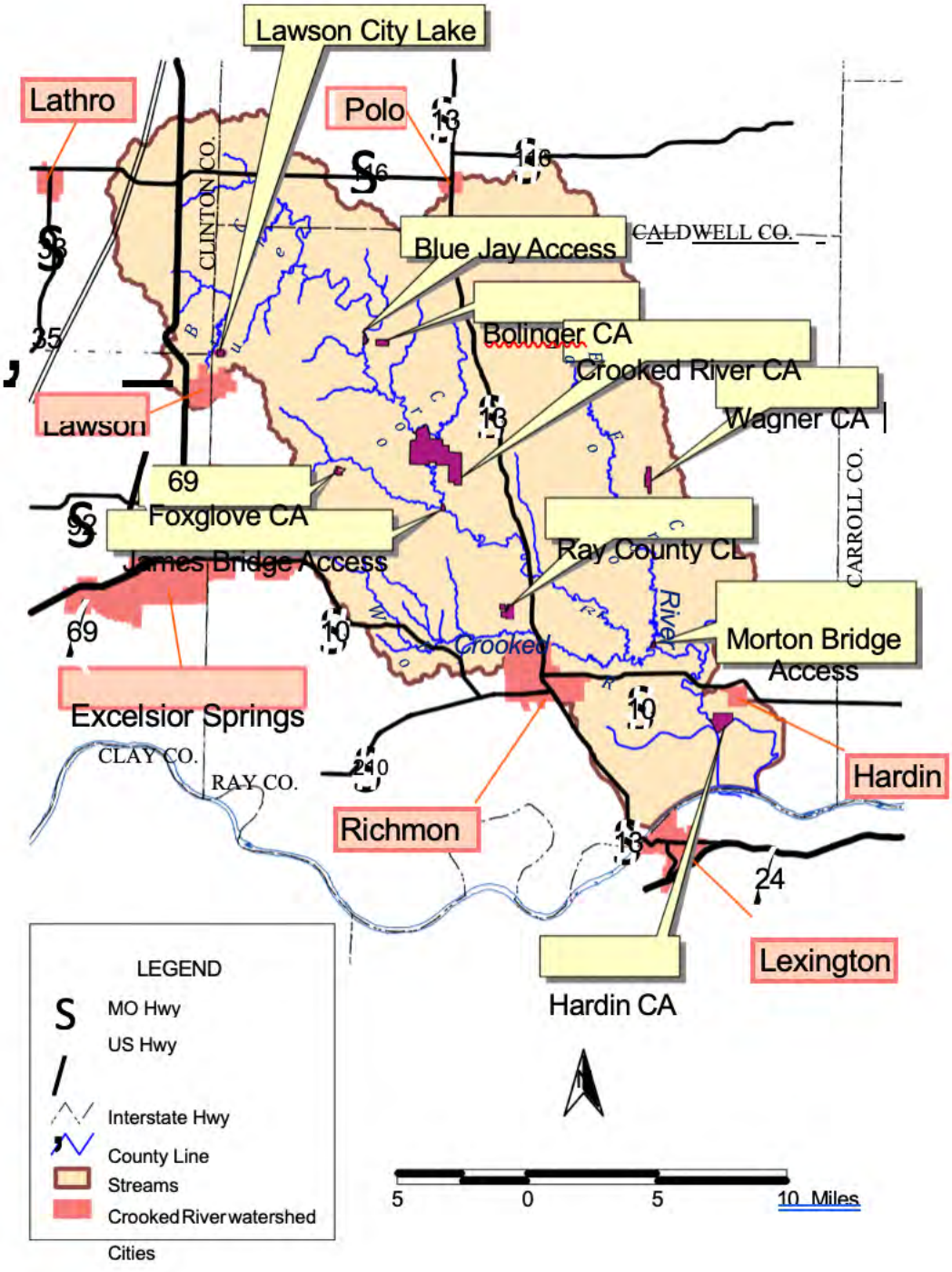


Table 1. Crooked River basin public areas.

Area Name	Size	Activities Permitted	Features	Ownership[1]
Crooked River CA	1420 acres	Hunting, Fishing, Camping, Hiking	Crooked River (3 miles frontage) and 22 acres of ponds, sloughs, and oxbows	MDC
Hardin CA	238	Fishing	Crooked River (1/4 mile frontage) 40 acre scour hole	MDC
unknown	unknown	Fishing	Boat ramp on Crooked River, West of Hardin	HSRD
Foxglove CA	54 acres	Hiking, Nature Observation	Rare species protection, non-consumptive use area	MDC
Wagner CA	130 acres	Hunting, Fishing	Cropland and forest, no stream frontage	MDC
Ray County Community Lake	159 acres	Fishing, Camping		
Blue Jay Trail Access		30 acres	Fishing, Camping	
James Bridge Access Bolinger CA	80 acres	Donated area, (still occupied 1998)	Will become MDC property when current owners decease	MDC
Lawson City Lake	25 acres	Fishing	CAP2 lake, disabled access, boat ramp, fishing berm	25 25 acre lake, disabled access, boat ramp, fishing berms
Morton Bridge Access	24 acres	Fishing, Camping	24 East Fork Crooked River/ Crooked River (1/3 mile frontage total)	Crooked River (3/4 mile frontage)

[1] - MDC, Missouri Department of Conservation; HSRD, Hardin Special Road District
[2] - Community Assistance Program (MDC provides assistance and manages the fishery)

Figure 2. Public land within the Crooked River basin.



Hydrology

Precipitation

Average annual precipitation for the Crooked River basin ranges from 36 to 38 inches (Vandike 1995). Average annual runoff is about 8.5 inches (Vandike 1995). Seventy percent of the rainfall occurs during the growing season (Preston 1986). Annual snowfall is about 20 inches (MDNR 1986a) with about 30 days of continuous snow cover (Detroy and Skelton 1983).

Gauging Stations

The two gauging stations in the Crooked River basin are both located near Richmond, Missouri. The gauge on the mainstem Crooked River (number 06895000; in operation from 1948 through 1970) was a continuous-record streamflow gauging station, located at the Highway 13 bridge, 4 miles north of Richmond and records data for a drainage area of 159 square miles. The other gauge (number 06895050; a low-flow station) located on the West Fork Crooked River at Richmond recorded data in 1943, 1945, 1946, 1953, and 1962 (Detroy and Skelton 1983).

Permanent and Intermittent Streams

The mainstem Crooked River was classified as permanently flowing for 30 miles and intermittently flowing for 30 miles in 1968. Estimates for the Crooked River basin, including the East and West Fork Crooked rivers, were 47 miles of permanent flowing and about 35 miles of intermittent flowing streams (Funk 1968).

There are 59 third order and larger streams in the Crooked River basin with a total stream mileage of 371 miles (Appendix B). The permanence/intermittence of particular streams can be determined from 7.5 minute series topographical maps found in the coverage in Appendix B. Permanent streams are indicated with solid blue lines and intermittent streams are indicated with dashed blue lines. Based on current USGS 7.5 minute maps there are 177 miles of permanently flowing and 50 miles of intermittently flowing streams and rivers, fourth order or higher, in the Crooked River basin. Most third order and lower streams in the basin are intermittent. Increased intermittence resulting from lower base flows and sedimentation is occurring throughout the basin. Crooked River basin streams suffer from poor baseflows due to the relatively impermeable nature of basin soils (MDNR 1986b).

Stream Flow

Average annual discharge for the gauging station on the mainstem Crooked River was about 99 cubic feet per second (DuCharme and Miller 1996). Lowest discharge usually occurs

midwinter and highest discharge in the summer months (Figure 3). The highest recorded flow was 29,000 cubic feet per second on July 20, 1965 (Vandike 1995). Periods of no flow have occurred in the Crooked River (Vandike 1995).

7 Day Q2 and Q10 Low Flows

Streams in the Dissected Till Plains Region, including the Crooked River, have poor low flow potentials due to low hydraulic conductivity of area soils and poor land use practices. Low flows in the basin usually occur in the months of August, September and October (Skelton 1976). Low flow characteristics can usually be generalized in plains streams based upon the size of the drainage area. Streams with basin areas less than 100 mi2 will almost always have 7-day average minimum flows at recurrence intervals of two years (7-day Q2) of zero. About 60 percent of plains streams with drainage areas of 100 to 200 mi2 will have 7-day Q2 of zero and the remainder will have 7-day Q2 of 0.1 to 1.0 cfs. This method is unreliable

for basins with drainage areas larger than 200 mi2, and field observations are required. The 7-day average minimum flows at 10 year intervals (7-day Q10) for drainage basins of 200 mi2 or less are almost always zero. About 70 percent of plains streams with drainage areas of 200 to 1,000 mi2 will have 7-day Q10 of zero and the remainder will have 7-day Q10 of 0.1 to 1.5 cfs (Skelton 1976). Lowest mean discharge in the Crooked River for 7 days consecutively is zero (Skelton et al. 1982). The 7 day Q2 is 0.2 and 7 day Q10 is zero (MDNR 1995). The flow duration curve (Figure 4) indicates the Crooked River basin has highly variable flows. Basin streams tend to rise and subside swiftly in response to precipitation events.

Dam and Hydropower Influences

There are no major dams in the basin. There are a few small public and private lakes and a large number of farm ponds in the Crooked River basin. In the early 1980's it was estimated that Ray County contained 3,500 small impoundments (Preston 1986). Due to small size and ease of construction, the number of ponds can change very rapidly. Many ponds are built without needing permits and statistics on ponds are usually compiled by county rather than watershed. These factors complicate getting accurate, up-to-date information on ponds. Concern exists over the effects these ponds have on low-flow conditions as they intercept runoff and allow little or no adjustment for maintenance of stream flows.

Appendix B. Stream information for third order and larger streams from the Crooked River basin obtained from 7.5 minute series, 1:24,000 scale, USGS topographic maps. (Original length and miles channelized for all streams fourth order and larger were estimated using 7.5 minute series, 1:24,000 scale, USGS orthophoto quadrangle maps).

Table B -1. Stream information for third order and larger streams from the Crooked River basin obtained from 7.5 minute series, 1:24,000 scale, USGS topographic maps. (Original length and miles channelized for all streams fourth order and larger were estimated using 7.5 minute series, 1:24,000 scale, USGS orthophoto quadrangle maps).

Stream Name	Max. Order	Location at Mouth T R S	Map Numbers1	Receiving Stream	Original Length (Mi.)	Current Length (Mi.)	Miles Channe l ized
Crooked River	6	51-26-14	S17, R17, R16, R15, Q15, Q14, P14, P13	Missouri River	78	71	5
Unnamed #01	3	51-26-8	S17, S16, R16	Crooked River		7	
Dangerous Branch	3	52-26-30	R17	Crooked River		6	
East Fork Crooked River	5	52-27-23	R16, Q16, P16	Crooked River	35	33	1
Unnamed #02	3	52-27-11	R16, R17	East Fork Crooked River		5	
Unnamed #03	3	53-27-35	R16, Q16	East Fork Crooked River		4	
Unnamed #04	3	53-27-35	R16, Q16	East Fork Crooked River		4	
Unnamed #05	4	53-27-9	Q16, P16	East Fork Crooked River		9	0
Unnamed #06	3	54-27-28	Q16	Unnamed #05		4	
Unnamed #07	3	54-27-21	Q16	Unnamed #05		3	
Unnamed #08	4	54-27-29	Q16, Q15, P15	East Fork Crooked River	14	13	2
Unnamed #09	3	54-27-30	Q16, Q15	Unnamed #08		3	
Unnamed #10	3	54-28-24	Q16, Q15	Unnamed #08		2	
Unnamed #11	3	54-28-11	Q15, P15	Unnamed #08		2	
Unnamed #12	3	54-28-11	P15	Unnamed #08		4	
Unnamed #13	3	55-28-35	P15	Unnamed #08		3	
Unnamed #14	3	54-27-17	Q16, P16	East Fork Crooked River		4	
West Fork Crooked River	4	52-27-27	R16, R15, R14	Crooked River		22	0
Unnamed #15	3	52-27-19	R16, R15	West Fork Crooked River		4	
Unnamed #16	3	52-28-21	R15	West Fork Crooked River		7	
Unnamed #17	3	52-27-8	R16	Crooked River		4	
Cottonwood Branch	3	52-27-7	R16, Q16	Crooked River		7	
McDonald Branch	4	53-28-36	R16, R15, Q15	Crooked River	7	7	1

Stream Name	Max. Order	Location at Mouth T R S	Map Numbers1	Receiving Stream	Original Length (Mi.)	Current Length (Mi.)	Miles Channe l ized
Unnamed #18	3	53-28-26	R15, Q15	McDonald Branch		4	
Unnamed #19	3	52-28-2	R15	Crooked River		1	
Rocky Fork	4	53-28-28	R15, Q15, Q14	Crooked River	12	11	1
Unnamed #20	3	53-28-29	R15	Rocky Fork		3	
Unnamed #21	3	53-29-24	Q15, Q14, R14	Rocky Fork		4	
Unnamed #22	3	53-29-14	Q15, Q14, R14	Rocky Fork		3	
Fire Branch	3	53-28-9	Q15, P15	Crooked River		12	
Kings Branch	3	53-28-6	Q15, Q14	Crooked River		4	
Coon Branch	3	54-29-25	Q15, Q14	Crooked River		5	
Cockerel Creek	4	54-28-19	Q15, P15	Crooked River	6	6	1
Unnamed #24	3	54-29-11	P14, P15	Crooked River		2	
Burnt Fork	4	54-29-9	P14, Q14	Crooked River	7	7	1
Unnamed #25	3	54-29-9	P14	Burnt Fork		1	
Unnamed #26	3	54-29-10	P14	Crooked River		2	
Unnamed #27	3	54-29-3	P14	Crooked River		3	
Unnamed #28	4	55-29-33	P14	Crooked River		4	0
Unnamed #29	3	55-29-27	P14	Unnamed #28		2	
Brushy Creek	4	55-29-33	P14, Q14	Crooked River	16	14	1
Unnamed #30	3	54-29-5	P14	Brushy Creek		2	
Unnamed #31	3	54-29-8	P14	Brushy Creek		2	
Unnamed #32	4	54-29-18	Q14, P14, P13	Brushy Creek		7	0
Unnamed #33	3	54-30-12	Q14, P14	Unnamed #32		1	
Unnamed #34	3	54-30-11	P14	Unnamed #32		2	
South Prong	4	55-29-28	P14	Crooked River	6	6	1
Unnamed #35	3	55-29-31	P14	South Prong		1	
Spring Branch	4	55-29-29	P14	Crooked River	5	4	1
Unnamed #36	3	55-29-20	P14	Spring Branch		2	
Stevenson Creek	4	55-29-29	P14, P13	Crooked River	11	10	1
Unnamed #37	3	55-29-19	P14	Stevenson Creek		3	
Unnamed #38	3	55-30-24	P14	Stevenson Creek		2	
Unnamed #39	3	55-30-23	P14, P13	Stevenson Creek		2	
Unnamed #40	3	55-30-25	P14	Crooked River		1	
Unnamed #41	3	55-30-35	P14	Crooked River		2	
Unnamed #42	4	55-30-35	P14, P13	Crooked River	4	3	1

Stream Name	Max. Order	Location at Mouth T R S	Map Numbers1	Receiving Stream	Original Length (Mi.)	Current Length (Mi.)	Miles Channe l ized
Unnamed #43	3	55-30-34	P14, P13	Unnamed #42		2	

Figure 3. Average annual discharge for the Crooked River basin at gauging station 06895000 near Richmond, Missouri (DuCharme and Miller 1996).

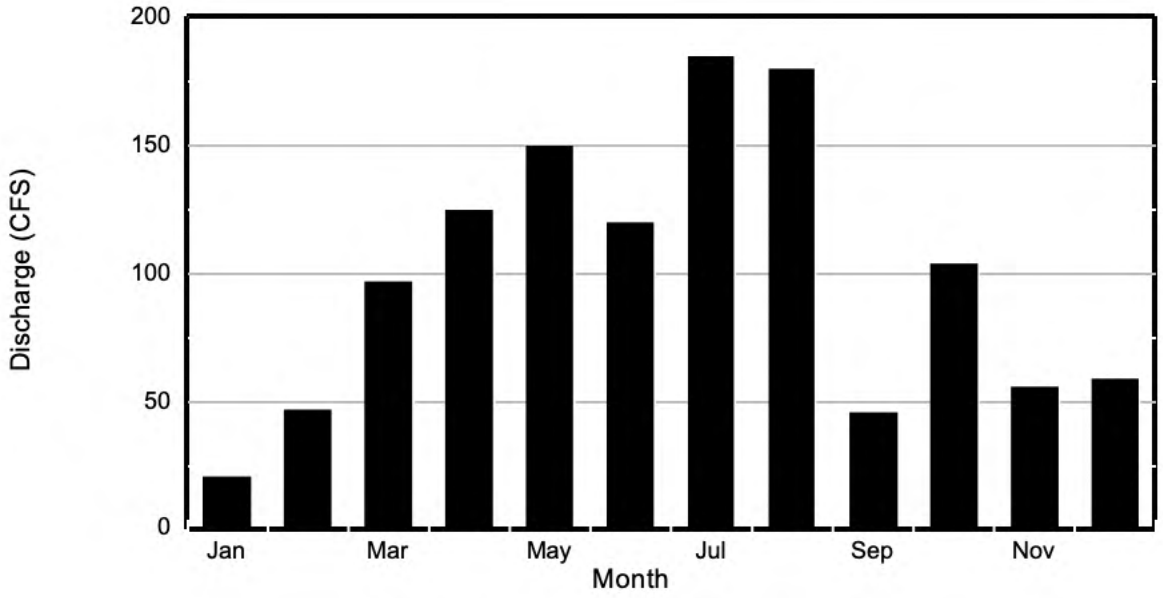
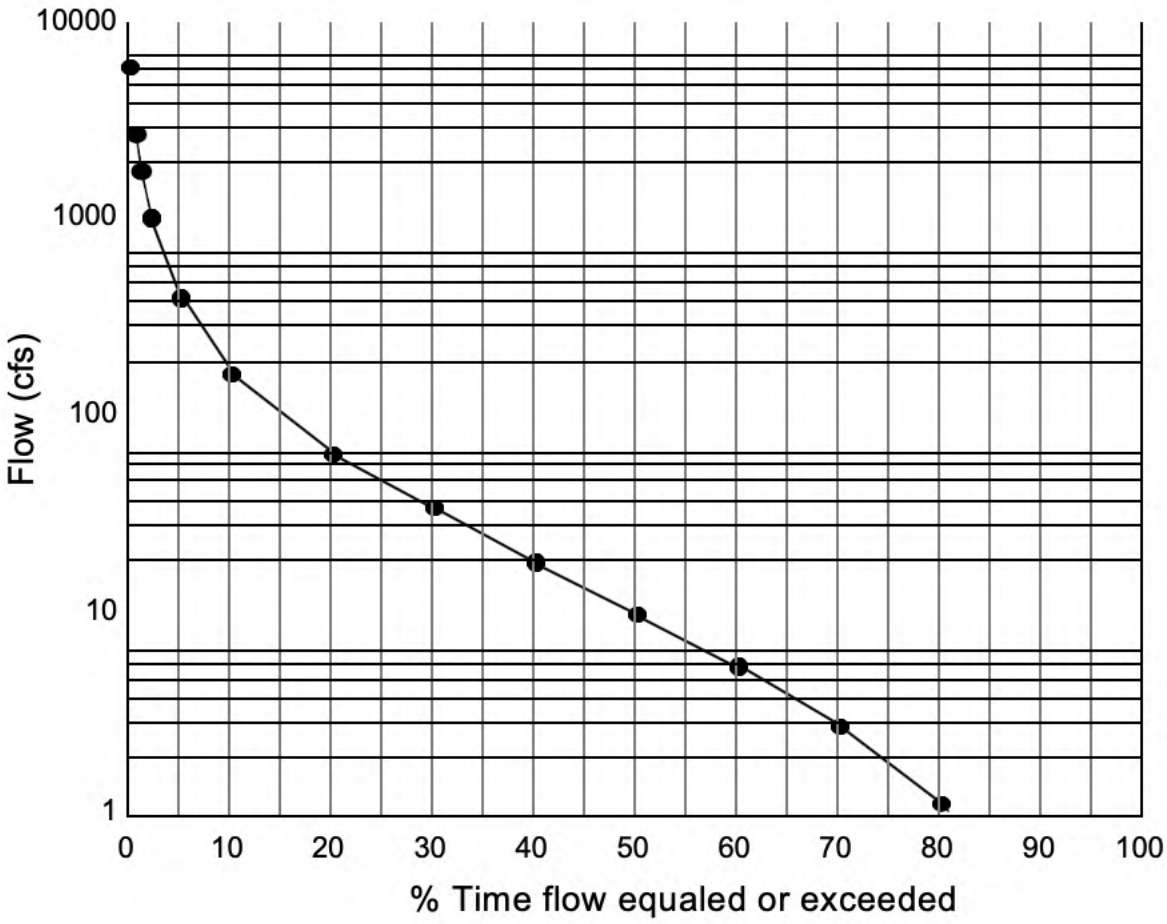


Figure 4. Flow duration curve for the Crooked River near Richmond, Missouri (Skelton 1976).



Water Quality and Use

Beneficial Use Attainment

The Crooked River basin is designated as suitable for aquatic life, fishing, wildlife and livestock watering (MDNR 1986b, MDNR 1995). Aquatic life and fishing are expected to be partially attained, although the numbers and diversity should remain relatively low due to non-point source suspended solids and sedimentation. Occasional low dissolved oxygen in short reaches may be caused by both point and non-point pollution sources. Water quality should be satisfactory for wildlife and livestock watering. (MDNR 1995) Soil erosion, sediment deposition and turbidity all contribute to aquatic habitat degradation. If erosion, stream channel modification, increasing nutrient inputs, and their related water quality problems continue, beneficial uses will not be attained in the future (MDNR 1986b).

Chemical Quality of Streamflow

It is probable that the streams in Northwest Missouri were historically prone to reduced water quality from turbidity and sediment due to the nature of the soils in the area. The activities of man, chiefly channelization and poor agricultural practices, have magnified sediment delivery, turbidity and their associated problems in the waters of Northwest Missouri (MDNR 1986b).

Historically, the water quality in the Crooked River basin has been good as Topeka shiners, a species sensitive to poor water quality, were found in the basin as late as 1965. The basin has more bedrock and gravel/cobble substrate, similar to that found in the Ozarks, than most other streams in northwestern Missouri. The lower sections of the basin (primarily the Missouri River flood plain) have been altered through extensive channelization and levees but the upper reaches are relatively undisturbed. The East Fork Crooked River from Millville upstream, rapidly becomes less turbid and rocky substrates become more common. The upper end of the West Fork Crooked River upstream of the Stewart Road/Highway 10 bridge area becomes quite rocky and clear. The mainstem Crooked River from Bluejay Access upstream rapidly clears and becomes Ozarkian in nature with bedrock, numerous gravel shoals and limestone bluffs present. Most of the tributaries above these areas are also clear and have rocky substrates. Localized areas are silty on these streams where channelization, agricultural or developmental activities are occurring. The water in the lower two thirds of the basin becomes progressively more turbid and silt laden. There is no documented quantitative water quality information for the Crooked River basin. However, water quality basin-wide is probably some of the best to be found in Northwest Missouri.

Water quality at low flows deteriorates due to lack of water volume to dilute point and non-point source pollution (MDNR 1986b). Soil erosion, sediment deposition and turbidity all contribute to water quality degradation (MDNR 1986b). Temperatures in excess of 27o C are detrimental to spawning and egg development of many fish (USDA-SCS 1982). Because of shallow water and low flows, this temperature may be exceeded in the Crooked River and its tributaries. Effects from sewage treatment plants are minor in the watershed (MDNR 1995). In general, water quality is good, but low flows and excessive sediment cause problems and threaten to further degrade water quality if current agricultural and developmental activities continue (MDNR 1986b).

Contaminants, Fish Kills, and Health Advisories

A general fish consumption advisory has been issued for all waters of Missouri, excluding the Ozarks, by the Missouri Department of Health (MDOH) since 1985 (MDOH 1996). The MDOH recommends eating no more than one pound per week of bottom feeding fish such as catfish, buffalo, drum, common carp, suckers and paddlefish from the Crooked River and its tributaries. No consumption advisories apply to bass, sunfish, crappie or walleye (MDOH 1996).

A possible threat to the basin is the increasing number of concentrated animal feeding operations. Manure

spills and improper land application of waste residues from these facilities have caused serious water quality problems and fish kills in other river basins in Missouri (MDNR 1996a). The reduced volume of water associated with low base flows could create serious problems for aquatic communities in the Crooked River basin if improper disposal practices at one of these facilities was to occur.

Water Use

A. **Municipal -** Population was projected to grow by about 35% over the 20 years from 1980 to 2000 (Skelton 1982). In actuality, population in Ray County only increased by 10% from 1980 to 1998 (U.S. Census Bureau Website). This indicates that pressure to develop water resources in the Crooked River Basin may be lower than anticipated. Municipal water use in the basin is about 737,889,500 million gallons per year (Ray County statistic; DuCharme and Miller 1996). Most municipal water is provided through rural water districts. They get their water primarily from groundwater wells tapping the Missouri River alluvium. These wells usually yield between 500 and 1500 gallons per minute. Millville obtains its water from an alluvial well along the East Fork Crooked River. Groundwater wells outside alluvial areas in the Crooked River basin usually are low yield (less than 5 gallons per minute) and high in chlorides and sulfates. Shallow low yield household wells drilled in glacial drift materials can be suitable for most domestic uses, however undesirable concentrations of nitrate, iron and manganese are commonly encountered in the Crooked River basin area (Detroy and Skelton 1983). Groundwater from deeper, higher yield wells is generally too mineralized (often greater than 10,000 ppm total dissolved solids) to be useable (MDNR 1986b). In general, the groundwater does not meet chemical drinking water standards of the U. S. Health Service (Preston 1986).

B. **Agricultural -** Irrigation has been a relatively minor use of water in the basin with less than 5,000 acres irrigated (Ray County statistic; DuCharme and Miller 1996). The largest agricultural users of water are livestock (100-175 million gallons per year used in Ray County; DuCharme and Miller 1996).

Point Source Pollution

The primary point source pollution in the Crooked River basin comes from wastewater treatment facilities (WWTF). These are located on a tributary of Brushy Creek (Lawson WWTF), unnamed tributary #8 on the East Fork Crooked River (Polo WWTF), and an unnamed tributary on the West Fork Crooked River (Richmond North WWTF; MDNR 1995). A 0.3 mile reach of Unnamed Tributary #8 was affected by sludge and reduced benthos from the Polo WWTF discharge (MDNR 1995). An unnamed second order tributary was suffering water quality problems as a result of the Richmond North WWTF discharge. Four miles of the West Fork Crooked River were affected by excessive aquatic plant growth and reduction of aquatic life below the Missouri State Highway 13 bridge crossing (MDC 1978). The Richmond North facility was upgraded in 1971 and the water quality was noted as dramatically improved (MDC files). Monitoring by the MDNR over several years indicated that water quality has improved downstream of the Richmond North WWTF through 1996 (MDNR personal communication). Most of the point source pollution permits issued in the Crooked River basin are located near the towns of Richmond and Henrietta, Missouri in the lower section of the basin (Table 2, Figure wt). Impacts from these sources would be seen primarily in the West Fork Crooked River, tributaries west of the mainstem Crooked River in the Missouri River floodplain and the lower Crooked River from its confluence with the West Fork Crooked River to the Missouri River. Without quantitative water quality information, it is not possible to gauge the impact of these discharges in the Crooked River basin.

Concentrated animal feeding operations (CAFOs) are a growing presence in the basin (12,946 Population Equivalency units (PE) in 1998). This is about three percent of the basin PE's attributable to livestock. A list of all permitted CAFOs in the basin can be found in Table 3 (Figure ca). There is a history of problems with discharges from these operations in other areas of Missouri. Serious impacts on water quality and aquatic organisms in the Crooked River basin would result should an effluent spill occur at

one of these facilities.

Household trash (including tires and appliances) was seen in basin streams at several locations. Also noticed were large gullies filled with trash. It appears that dumping in and along basin streams is a common practice.

Non-Point Source Pollution

The main threat to aquatic resources in the Crooked River basin is sediment from erosion. This particular problem is found throughout the watershed. The estimated sediment yield for the Crooked River basin area was 750 - 1000 tons per square mile per year (Skelton et al. 1982) or about 2.6 tons per acre per year (Anderson 1980). Sheet and rill erosion was estimated to be 18-24 tons per acre per year for tilled land,

5-9 tons per acre per year for pasture and 0.25 to 0.5 tons per acre per year for non-grazed forest lands in the Crooked River basin. Gully erosion in the basin was rated as severe with the yield to streams from this source ranging from 200 - 499 tons per square mile per year (Anderson 1980). In the area, including the Crooked River basin, the source of sediments was estimated to be 74% sheet and rill erosion, 22% gully erosion, 3% streambank erosion and 1% urban development (Anderson 1980). There are concerns with elevated levels of agricultural herbicides, in particular atrazine, during the spring and summer in streams that are used to augment drinking water supplies (MDNR 1996a). As of 1996, there were no municipal surface water drinking supply withdrawals in the Crooked River basin (MDNR 1996b).

Ray County has 160,000 acres that are considered prime farmland (109,000 acres have the caveat "where drained" applied to them). Of this amount, 38,000 acres are on ridgetops with less than a 5 percent slope. The remainder are on alluvial soils associated with the floodplains of the Missouri River and its tributaries (Preston 1986). Alluvial farmland in the basin would be limited, as the floodplain is not very wide until it merges with the Missouri River floodplain. The area where the Missouri River floodplain and the Crooked River floodplain intersect takes in about four miles of the lower Crooked River. This area is very flat, fertile and floodprone. Channelization of the mouth of the Crooked River and several of its floodplain tributaries has been carried out in order to drain and cultivate this area.

The number of livestock in the Crooked River basin is equivalent to a human population of 437,550. This figure was obtained using the Missouri River basin (hydrologic river basin number 10300101) statistic for livestock (2,917,000 Human population equivalency units [PE]) and multiplying it by the percentage of the basin in the Crooked River watershed (15% [2,917,000 PE X .15 = 437,550 PE]). This is about twenty times the size of the basin population (21,971 people in Ray County). The majority (97%) of livestock are ranging animals and have access to basin streams. Stream bank erosion and excess nutrients are two known problems caused by unrestricted access of livestock.

Coal mining operations were conducted in the Crooked River basin from the 1870's to the 1950's. There were four general areas in the Crooked River drainage that were mined for coal (Figure 5). One was between Polo and Knoxville near the headwaters of the Fire Branch. Another was east of Knoxville just below the confluence of the East Fork Crooked River and Unnamed Tributary # 8. The third area was along the West Fork Crooked River near Richmond. The fourth area was near the mouth of the old Crooked River channel (Detroy and Skelton 1983). Many of these areas can be located in more detail using the 7.5 minute series topographical maps listed in Appendix C. The area of the Crooked River from the confluence of the West Fork Crooked River and mainstem Crooked River to the Missouri River was projected as an area of potential future surface coal mining (Skelton et al. 1982). Most of the Crooked River basin is underlain by surface mineable coal (Detroy and Skelton 1983).

In 1978, several areas in the Crooked River basin were noted as being impacted by non-point source pollution (Figure 5). Using aerial photographs and topographical maps it appears these areas were impacted because of upstream channelization though it was not specifically mentioned. The following reaches were noted as impacted from both sediment and reduced instream habitat: 20 miles of the Crooked River in Caldwell and Ray counties below the road crossing in T55N, R29W, Sec 29, 17 ½

miles of the Crooked River below the Missouri State Highway 13 crossing north of Richmond, and two miles of the Fire Branch in Ray County below the road crossing in T53N, R28W, Sec 3 (MDC 1978).

Table 2. Permitted point source discharges in the Crooked River basin.

Facility	Facility ID	Location (T-R-S)	Receiving Stream	County
Polo WWTF	MO0041238	55N-28W-27	Unnamed tributary #08	Caldwell
Lawson	ND7100444	54N-29W-31	Tributary to Brushy Creek	Ray
Lawson WWTF	MOG640003	54N-29W-30	Tributary to Brushy Creek	Ray
MFA Agri Service Lawson	MOR240381	54N-29W-30	Tributary to Brushy Creek	Ray
Organic Matters Composting	MOG970003	53N-27W-03	Tributary to East Fork Crooked River	Ray
Richmond N. WWTF	MO0021822	52N-27W-19	Tributary to West Fork Crooked River	Ray
Richmond Quarry	MOG490208	52N-28W-19	Tributary to West Fork Crooked River	Ray
Russell & Sons Fertilizer	MOR240418	53N-27W-16	Tributary to East Fork Crooked River	Ray

Figure wt/ca. Wastewater treatment facilities and concentrated animal feeding operations within the Crooked River watershed.

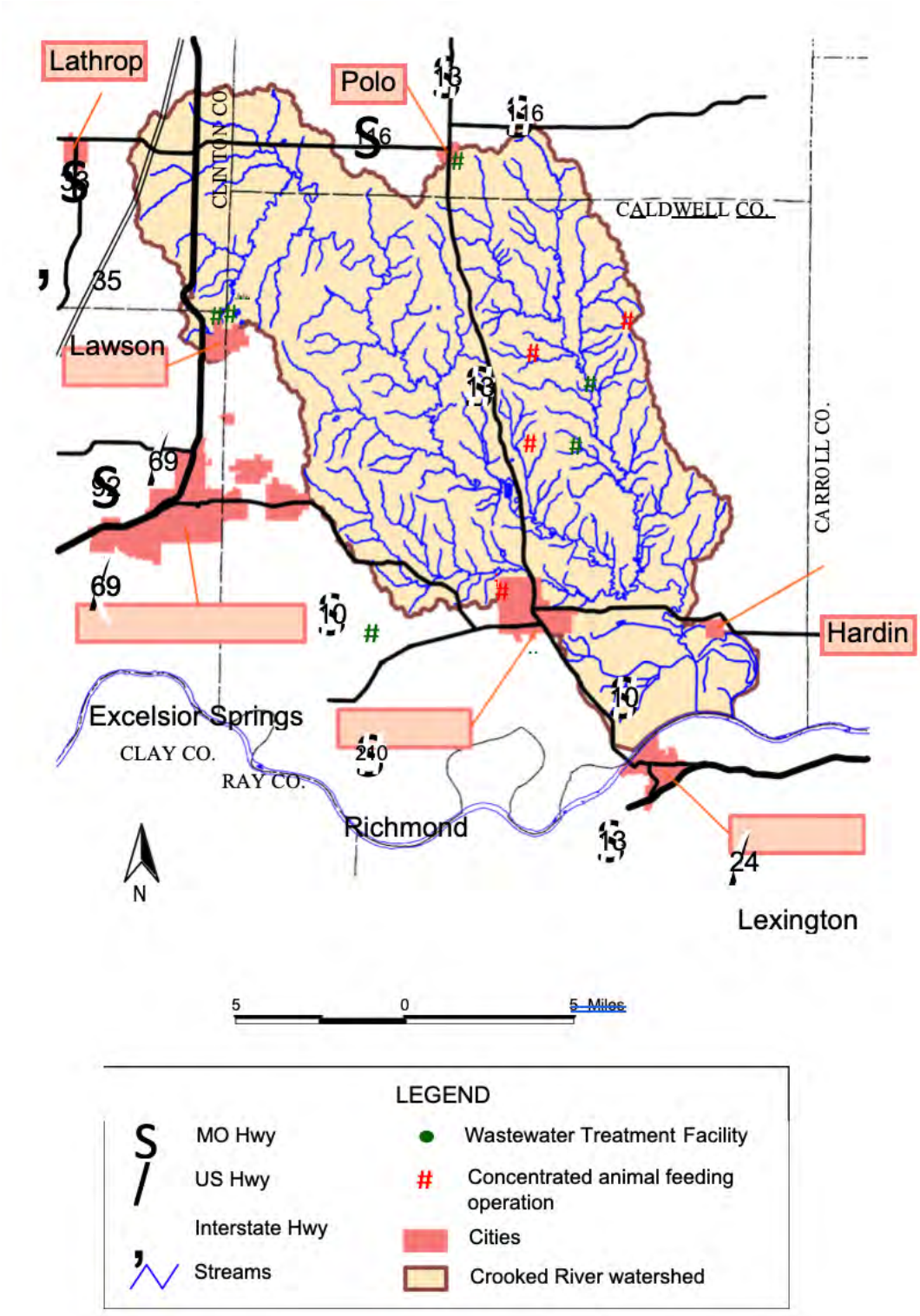
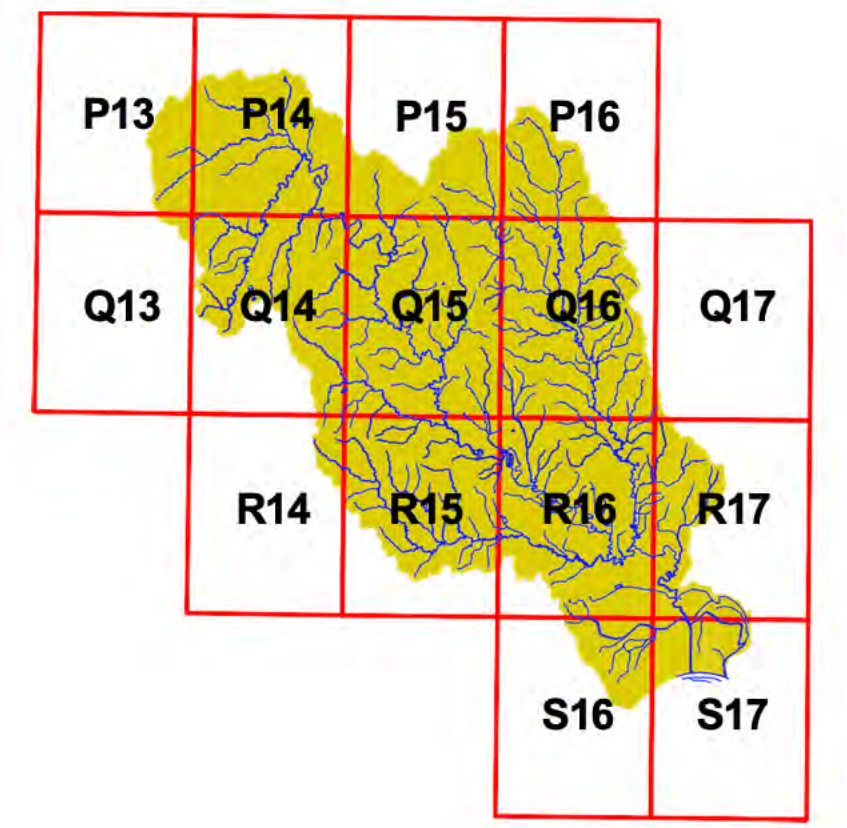


Table 3. Permitted concentrated animal feeding operations (CAFOs) in the Crooked River basin.

Facility	Facility ID	County	Design Pop. Equivalent	Animal Units	Animal Type1	Location (T-R-S)
Earl Carter	LA7000362	Ray	1056	480	SF	52N-28W-12
Jerry Miller	LA7103827	Ray	4320	1920	SF	53N-27W-06
Laverne Schlavach	LA7103834	Ray	4500	2000	SF	53N-27W-18
Snead Brothers	LA7100953	Ray	2970	1350	SF	54N-27W-26
Wayne Ulbright	LA7100507	Ray	100	4	HS	52N-28W-01

Appendix C. 7.5 minute series, 1:24,000 scale, USGS topographic map quadrangles and indexing system used in the Crooked River basin.



13	14	15	16	17	
Lathrop (1984)	Elmira (1984)	Polo (1984)	Cowgill (1984)		P
Holt (1990)	Lawson (1990)	Knoxville (1979)	Millville (1979)	Stet (1979)	Q
	Excelsior Springs (1990)	Rayville (1979)	Richmond (1979)	Hardin (1978)	R
			Lexington West (1979)	Lexington East (1978)	S

Habitat Conditions

Channel Alterations

The mouth of Crooked River was moved through channelization and levying in 1969 by the U. S. Army Corps of Engineers (USCOE) and resulted in a loss of six miles of river channel (MDC files). The Crooked River was channelized for 3 miles (starting about 1/4 mile north of the road crossing in T51N, R26W, Sec 6) and the original river channel became an isolated cutoff as a result of the modification by the USCOE (MDC 1978). The old channel mouth was plugged with a 60 inch pipe and a two way valve was installed to allow fish passage at normal water levels by the Henrietta Crooked River Drainage and Levee District (HCRDLD) in 1971-1972. This was to reduce problems with the Missouri River backing water up in the cutoff section during high water periods. Recurring problems with the HCRDLD pumping water in the cutoff below the agreed level (672.5' MSL) was documented through 1990 (MDC Ray County environmental files). In a May 1992 MDC memo (H. Kerns, NW Regional fisheries supervisor) it was noted that even with a gauge reading of 672.5' MSL the old Crooked River cutoff channel from the county road bridge to the Missouri River was just a "few isolated pockets of water" and the area appeared to have been "pumped dry". It was also mentioned that an extra two feet or even more of water in the channel would greatly benefit the fishery without affecting the surrounding row crop land. The status of this long running problem at the current time (1998) is unresolved. However, the old channel cutoff remains an important wetland and fishery resource in the Crooked River basin.

Channelization of several tributaries to the lower Crooked River was noted as of February 1978. A 4 mile reach below the road crossing at T51N, R27W, Sec 3 and a 9 mile reach of tributaries starting in T51N, R27W, Sec 10 were channelized (MDC 1978). These are located in the Missouri River floodplain, east of the town of Henrietta, Missouri. With only 14% of basin stream mileage modified by channelization (Table 4) the Crooked River basin is one of the least disturbed stream systems in Northwest Missouri.

Areas of stream modification were located using orthophoto quadrangle and topographic maps and areas in the Crooked River basin that are noticeably affected by channelization are shown in Figure 6. Most of these areas are downcutting at the present time. In the upper third of the basin bedrock and gravel have limited the effects of headcutting caused by channelization. In the downstream reaches the effects from channelization are more pronounced with very steep incised channels. It appears that widening of the incised channels may be starting to occur as trees and woody debris are more frequently encountered in the area between Crooked River Conservation Area and Morton Bridge Access.

Unique Habitat

The Crooked River basin is near the transition area between the glaciated plains and the Osage plains and has a unique mix of habitats as a result. The Crooked River has more rocky substrate and is less altered than most of the streams in northwestern Missouri making it a unique resource. It is also very close to a large urban population (Kansas City) making its value as an aquatic resource even higher. The area on the Missouri River floodplain around the mouth of the Crooked River is where the wetlands in the basin are found. Wetland acreage has increased in the Crooked River basin since the mid 1950's. The increases were in shallow and deep marshes (USDA-SCS 1982). A large scour hole (approximately 40 acres in size) in the channelized lower Crooked River is frequently fished by local anglers and has the potential to be an excellent fishery resource. Some unique habitats identified in a natural features inventory (Gremaud 1987) as significant were a dry mesic prairie and a mesic forest. Notable habitats were a dolomite savanna and a moist limestone bluff. Also notable, was a section of unchannelized prairie river (Crooked River from T54N, R29W, Sec 14 to T53N, R28W, Sec 28) in an agricultural watershed.

Improvement Projects

A streambank stabilization project installed June through September 1988, on the Crooked River CA, is the only improvement project documented in the Crooked River basin. It consists of a rock barb, a tree revetment and willow stake planting to protect a county road. A large logjam was removed with dynamite prior to project construction. Most of the problem area was stabilized, but a small area at the downstream end of the project was creating a scoured bank. Further work and assessment was recommended in 1993 by MDC.

Stream Habitat Assessment

The Crooked River basin streams vary widely in the quality and variety of habitat found in and along them. Some reaches feature clear water, rocky substrates, and are Ozarkian in nature while others are muddy drainage channels with substrates of clay, silt, and detritus. Large woody debris (log jams, rootwads, laydowns, etc.) can be found in streams throughout the basin. Areas of unconsolidated bottom sediments (sand and silt) can be found basin-wide but are less frequently encountered in the upper third of the watershed. Most basin streams have wooded corridors although they vary considerably in width and density. However, there are areas in the basin where agricultural fields are extended to the edge of streams and the wooded corridor has been eliminated.

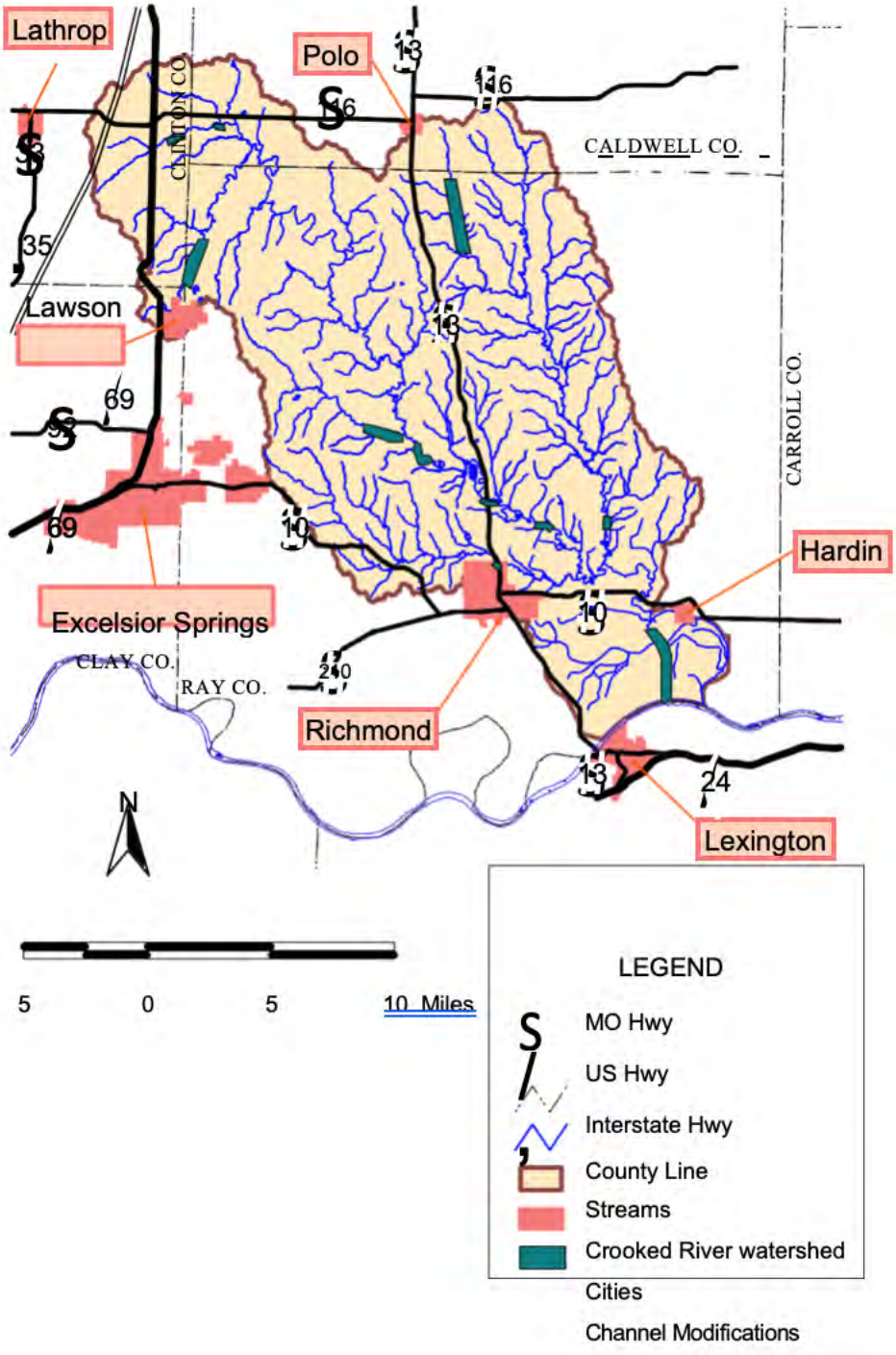
Stream channels in the lower Crooked River basin are deeply incised due to downcutting caused by channelization. Channelization increases the velocity of a stream which in turn increases erosion of the streambed and stream banks. Additional effects of channelization on basin streams are increased erosion, increased sediment bedload, steepened banks, and increased instream woody debris. The upper reaches of the basin where the streambed is predominantly bedrock, show less effect from downcutting and erosion than the lower reaches in the basin. Stream bed and bank modification was apparent at several bridges in the basin. From visual observation, agricultural activities in the upper part of the basin appear to consist primarily of pasture grazing and hay operations with row crops predominant in lower areas of the basin. This may be a reason for improved water clarity as you move progressively higher in the basin.

Crooked River basin streams are degraded but with a little help (improved agricultural practices, increased forested corridor width, and no additional stream alteration) can probably be rejuvenated. The Crooked River basin is one of the last stream systems in Northwest Missouri where this may be possible.

Table 4. Miles of channelization for streams fourth order and larger in the Crooked River basin.

Order	Streams (number)	Streams Unaltered	Original Miles	Miles Unchannelized (% of orig.)	Miles Altered (% of orig.)	Current Miles	Miles Channelized (% of current)
6	1	0	78	66 (85)	12 (15)	71	5 (7)
5	1	0	35	32 (9)	3 (9)	33	1 (3)
4	14	4	130	112 (86)	18 (14)	123	11 (9)
4,5,6	16	4	243	210 (86)	33 (14)	227	17 (7)

Figure 6. Areas in the Crooked River basin that are noticeably affected by channelization, located using orthophoto quadrangle and topographic maps.



Biotic Community

Fish Community Data

Limited sampling of the lower Crooked River mainstem was done in 1941. The area was altered by channelization in the early 1970's, and the fish assemblage has probably changed since 1941 due to these modifications. The middle portion of the Crooked River basin and the tributaries in the eastern part of the basin have been minimally sampled. Most efforts appear to have been concentrated in the Rocky Fork, upper reaches of the East Fork Crooked River, West Fork Crooked River and mainstem Crooked River.

Some new areas that were sampled for the first time in 1998 were Brushy Creek, Fire Branch, Cottonwood Branch, West Fork Crooked River below Richmond, and Unnamed Tributary # 5.

Twenty-one sites scattered throughout the Crooked River basin were scheduled for sampling during 1998 (Figure 7). Five sites on the mainstem Crooked River were inadequately sampled or not sampled for various reasons. Hazardous weather (RAH98-7) and difficult sampling conditions (steep slick mud banks and deep water; RAH98-1, RAH98-5) reduced sampling efforts at three sites. Two other sites were dropped, one due to steep mud banks and deep water (RAH98-6) and the creek bed was dry at the other site (RAH 98-15).

There were 39 species of fish collected in the Crooked River basin in 1998 (Table 5). Fish species captured for the first time in the basin in 1998 were paddlefish, goldfish, grass carp, bighead carp, silver chub, bigmouth buffalo, western mosquitofish, white bass and freshwater drum. Fish captured in 1995 and 1998 but not previously included: Golden shiner, black crappie and logperch. All of the fish collected for the first time in 1998 were captured in the lower Crooked River near or in the Missouri River floodplain. The grass carp and bighead carp are introduced species that have become established since 1941 when this area was last sampled.

Western mosquitofish have probably arrived by natural range expansion and/or inadvertent introduction. Goldfish have probably been introduced by bait bucket releases of anglers. The paddlefish, bigmouth buffalo, white bass and freshwater drum were likely present but not sampled in 1941 because seining was the only collection gear used. These species were collected using a boat mounted electrofisher in 1998.

Silver chubs were historically found in large prairie streams and the Missouri River in Northwest Missouri. The single specimen captured in 1998 in the lower Crooked River may have been a migrant from the Missouri River as it is regularly found there. The three species of fish captured since 1995, golden shiner, logperch and black crappie, were found over a large area of the basin including headwater areas. The logperch were captured primarily in the middle section of the Crooked River basin. They may have been present in the Crooked River basin for quite some time, but lack of sampling in the middle section of the basin may have been the reason they have only recently been captured. Golden shiner has probably been introduced through bait bucket releases of anglers. Black crappie probably have been introduced via farm pond stocking or lake overflows. Species that were widespread and commonly encountered in the basin included central stoneroller, red shiner, common shiner, sand shiner, creek chub, black bullhead, green sunfish and bluegill. A list of species collected by site is found in Appendix E.

The only species collected previously in the Crooked River basin that was not collected in 1998 was the Topeka shiner. This species was collected in the upper Crooked River in 1965 but was not captured in intensive collecting in headwater areas in 1995 (including the historic collection site, Gelwicks and Bruenderman 1996) or 1998. Apparently, the Topeka shiner has disappeared from the Crooked River basin. Creel survey records for the Crooked River basin include rock bass, smallmouth bass, and flathead catfish. None of these species were collected in recent sampling, although flathead catfish undoubtedly occur in the basin. There are no other records for smallmouth bass and rock bass in the Crooked River basin. These fish may have been identified incorrectly by untrained creel personnel.

Aquatic Invertebrates

Steve Eder (MDC) collected aquatic invertebrate information on the mainstem Crooked River in September 1987. There were 2,227 invertebrates collected representing 13 different orders. Detailed information is presented in Appendix F. Sampling of adult dragonflies in the Crooked River basin in Missouri was conducted in July and September, 1997 by Linden Trial (MDC, personal communication). These results are also found in Appendix F.

Four crayfish have ranges that include part or all of the Crooked River basin (Table 6). Very little collecting has been conducted to confirm or document their occurrence in the basin. The devil crayfish spend most of their lives underground and are difficult to collect and document. The grassland crayfish is also a burrowing crayfish that can be difficult to collect (Pflieger 1996). The only species of crayfish collected in 1998 were northern crayfish (Table 6).

There are several mussels whose range includes the Crooked River watershed, but very little sampling has been conducted to determine their presence. Mussels in general are declining in Missouri primarily due to habitat loss. Weathered shells from the Crooked River were collected in July and September 1997 by Linden Trial (Table 7). The collection is the only documented record of mussels in the Crooked River system that could be found. Several weathered shells were collected during sampling in May and June of 1998.

Amphibians and Reptiles

Table 8 lists the amphibians found in the Crooked River basin. Three species, the plains spadefoot, great plains toad and great plains narrowmouth toad, are restricted to the area of the Missouri River floodplain. Due to their secretive nature and life history habits, these three species are difficult to study and document through collection. Table 9 lists the reptiles found in the Crooked River basin.

Threatened and Endangered Species

The Topeka shiner was last collected in the Crooked River basin in 1965. An intensive effort to collect Topeka shiners was carried out in the basin in 1995 (Gelwicks and Bruenderman 1996). None were collected in sampling in 1995 or 1998. It appears that the Topeka shiner has been extirpated from the Crooked River basin. A remnant population of greater prairie-chickens was found by Ray County senior conservation agent George Hiser in 1990 and confirmed with follow up observations by other MDC personnel. A rare plant, auriculate false foxglove, is found on the Foxglove CA.

Rare or unusual species reported from the Crooked River basin include scorpions, Bell's vireo, armadillos and badgers. Pheasants, an introduced game bird, are observed occasionally in the Crooked River basin (G. Hiser, MDC Conservation Agent, pers. comm.). (Table 10).

Fish Stocking

Fish stocking has been carried out in the Crooked River basin by the MDC and private individuals. The basin's public lakes are stocked and managed by the MDC. A complete list of fish stocked in state-managed waters can be found in Table 11. The MDC offers a stocking program for private impoundments that meet the eligibility requirements. The MDC supplies largemouth bass, bluegill and channel catfish to eligible impoundment owners for initial stocking.

Private impoundments are often supplementally stocked by their owners with fish purchased from commercial fish producers. Black and white crappie (probably native to the basin) have been stocked in private impoundments and appear throughout the basin. Grass carp have been stocked in private impoundments throughout the basin to control aquatic vegetation, and escapement has occurred.

Immigration from the Missouri River may be occurring as natural reproduction has been documented in the lower Missouri River (Brown and Coon 1994). Common carp are also an introduced species that are

present in the basin and provide angling opportunity. Bighead carp, another introduced species, was captured during basin sampling in 1998 and are probably immigrating from the Missouri River where they have become established.

Creel Survey

A statewide creel survey by Funk (1968) indicated common carp, bullheads, and channel catfish were the most frequently harvested fish in the Crooked River basin. Other fish in the Crooked River, creeled by anglers, included bluegill, crappie, green sunfish, largemouth bass, smallmouth bass, rock bass, and flathead catfish. Some of these records (smallmouth bass and rock bass in particular) may be erroneous as information was collected by personnel with minimal training in fish identification.

Present Regulations

Statewide creel and fish size limits apply to the streams and rivers in the Crooked River basin. Special size restrictions, creel limits or other regulations apply to public impoundments in the basin.

Figure 7. Fish sample locations in the Crooked River basin.

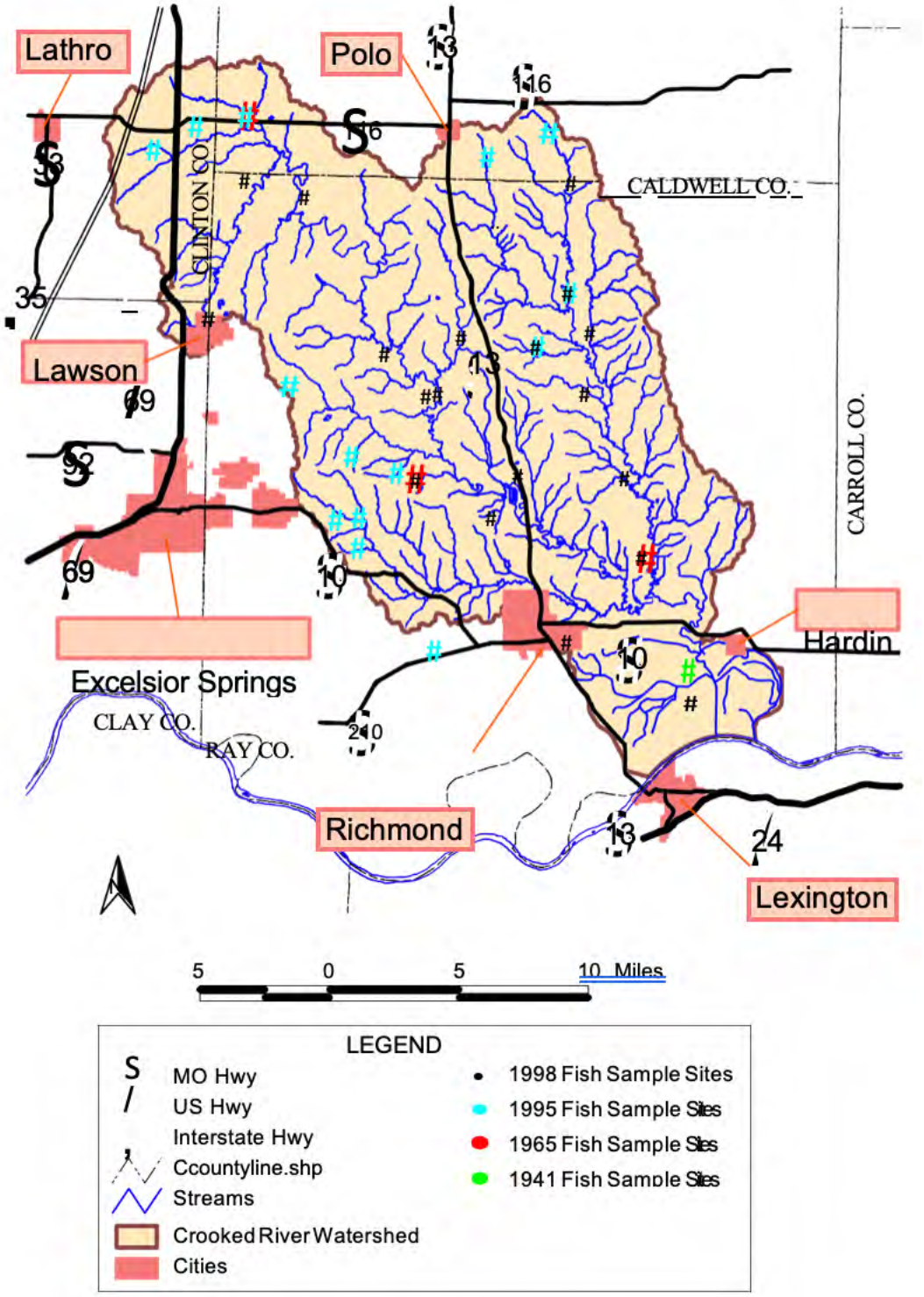


Table 5. Fish collected in the Crooked River basin (MDC files)

Common Name	Scientific name	1941	1965	1995	1998
Paddlefish	*Polyodon spathula*				X
Shortnose Gar	*Lepisosteus platostomus*	X			X
Gizzard Shad	*Dorosoma cepedianum*	X	X		X
Central Stoneroller	*Campostoma pullum*		X	X	X
Goldfish	*Carassius auratus*				X
Grass Carp	*Ctenopharyngodon idella*				X
Red Shiner	*Cyprinella lutrensis*	X	X	X	X
Common Carp	*Cyprinus carpio*	X	X		X
Bighead Carp	*Hypophthalmichthys nobilis*				X
Common Shiner	*Luxilus cornutus*		X	X	X
Western Redfin Shiner	*Lythrurus u. umbratilis*		X	X	X
Silver Chub	*Macrhybopsis storeriana*				X
Golden Shiner	*Notemigonus crysoleucas*			X	X
Emerald Shiner	*Notropis atherinoides*	X			X
Bigmouth Shiner	*Notropis dorsalis*		X	X	X
Sand Shiner	*Notropis ludibundus*		X	X	X
Topeka Shiner	*Notropis topeka*		X		
Suckermouth Minnow	*Phenacobius mirabilis*		X	X	X
Bluntnose Minnow	*Pimephales notatus*		X	X	X
Fathead Minnow	*Pimephales promelas*	X	X	X	X
Creek Chub	*Semotilus atromaculatus*		X	X	X
River Carpsucker	*Carpiodes carpio*		X	X	X
White Sucker	*Catostomus commersoni*		X	X	X
Smallmouth Buffalo	*Ictiobus bubalus*	X			X
Bigmouth Buffalo	*Ictiobus cyprinellus*				X
Black Bullhead	*Ameiurus melas*	X	X	X	X
Yellow Bullhead	*Ameiurus natalis*	X		X	X
Channel Catfish	*Ictalurus punctatus*		X	X	X

Common Name	Scientific name	1941	1965	1995	1998
Western Mosquitofish	*Gambusia affinis*				X
White Bass	*Morone chrysops*				X
Green Sunfish	*Lepomis cyanellus*		X	X	X
Orangespotted Sunfish	*Lepomis humilis*	X	X	X	X
Bluegill	*Lepomis macrochirus*		X	X	X
Largemouth Bass	*Micropterus salmoides*		X	X	X
White Crappie	*Pomoxis annularis*		X	X	X
Black Crappie	*Pomoxis nigromaculatus*			X	X
Johnny Darter	*Etheostoma nigrum*		X	X	X
Orangethroat Darter	*Etheostoma spectabile*		X	X	X
Logperch	*Percina caprodes*			X	X
Freshwater Drum	*Aplodinotus grunniens*				X

Appendix E. Fish samples from the Crooked River basin.

Table E - 1. Fish sampled from the mainstem Crooked River (site MRW98-9) in the Crooked River basin on May 5, 1998.

Common Name	Scientific Name	Number Collected
Paddlefish	*Polyodon spathula*	1
Shortnose Gar	*Lepisosteus platostomus*	16
Gizzard Shad	*Dorosoma cepedianum*	42
Red Shiner	*Cyprinella lutrensis*	46
Golden Shiner	*Notemigonus crysoleucas*	1
Sand Shiner	*Notropis ludibundus*	3
Emerald Shiner	*Notropis atherinoides*	24
Bluntnose Minnow	*Pimephales notatus*	5
Silver Chub	*Macrhybopsis storeriana*	1
Creek Chub	*Semotilus atromaculatus*	1
Goldfish	*Carassius auratus*	2
Common Carp	*Cyprinus carpio*	22
Grass Carp	*Ctenopharyngodon idella*	1
Bighead Carp	*Hypophthalmicthys nobilis*	1
River Carpsucker	*Carpiodes carpio*	17
Smallmouth Buffalo	*Ictiobus bubalus*	4
Bigmouth Buffalo	*Ictiobus cyprinellus*	15
Channel Catfish	*Ictalurus punctatus*	14
Western Mosquitofish	*Gambusia affinis*	4
White Bass	*Morone chrysops*	3
Largemouth Bass	*Micropterus salmoides*	6
Bluegill	*Lepomis macrochirus*	8
Green Sunfish	*Lepomis cyanellus*	9
White Crappie	*Pomoxis annularis*	2
Black Crappie	*Pomoxis nigromaculatus*	1
Freshwater Drum	*Aplodinotus grunniens*	8

Table E - 2. Fish sampled from the East Fork Crooked River (site RAH 98-1) in the Crooked River basin on May 14, 1998.

Common Name	Scientific Name	Number Collected
Yellow Bullhead	*Ameiurus natalis*	1
Bluegill	*Lepomis macrochirus*	4

Table E - 3. Fish sampled from the East Fork Crooked River (site RAH 98-2) in the Crooked River basin on May 14,1998.

Common Name	Scientific Name	Number Collected
Central Stoneroller	*Campostoma pullum*	1
Red Shiner	*Cyprinella lutrensis*	48
Common Shiner	*Luxilus cornutus*	25
Western Redfin Shiner	*Lythrurus u. umbratilis*	2
Golden Shiner	*Notemigonus crysoleucas*	1
Sand Shiner	*Notropis ludibundus*	4
Bluntnose Minnow	*Pimephales notatus*	7
Black Bullhead	*Ameiurus melas*	1
Yellow Bullhead	*Ameiurus natalis*	1
Green Sunfish	*Lepomis cyanellus*	11
Bluegill	*Lepomis macrochirus*	1
Ozark Logperch	*Percina caprodes*	2

Table E - 4. Fish sampled from the West Fork Crooked River (site RAH 98-3) in the Crooked River basin on May 14,1998.

Common Name	Scientific Name	Number Collected
Central Stoneroller	*Campostoma pullum*	2
Red Shiner	*Cyprinella lutrensis*	
Common Shiner	*Luxilus cornutus*	17
Sand Shiner	*Notropis ludibundus*	1
Bluntnose Minnow	*Pimephales notatus*	6
Suckermouth Minnow	*Phenacobius mirabilis*	3
Creek Chub	*Semotilus atromaculatus*	18
White Sucker	*Catostomus commersoni*	2
Black Bullhead	*Ameiurus melas*	1
Green Sunfish	*Lepomis cyanellus*	4
Bluegill	*Lepomis macrochirus*	3
Largemouth Bass	*Micropterus salmoides*	1
Orangethroat Darter	*Etheostoma spectabile*	1
Ozark Logperch	*Percina caprodes*	1

Table E - 5. Fish sampled from the Cottonwood Branch (site RAH 98-4) in the Crooked River basin on May 14, 1998.

Common Name	Scientific Name	Number Collected
Central Stoneroller	*Campostoma pullum*	3
Red Shiner	*Cyprinella lutrensis*	2
Fathead Minnow	*Pimephales promelas*	12
Creek Chub	*Semotilus atromaculatus*	20
Green Sunfish	*Lepomis cyanellus*	1

Table E - 6. Fish sampled from the mainstem Crooked River (site RAH 98-5) in the Crooked River basin on May 14, 1998.

Common Name	Scientific Name	Number Collected
Central Stoneroller	*Campostoma pullum*	1
Creek Chub	*Semotilus atromaculatus*	3
Black Bullhead	*Ameiurus melas*	1
Green Sunfish	*Lepomis cyanellus*	4

Table E - 7. Fish sampled from the mainstem Crooked River (site RAH 98-7) in the Crooked River basin on May 14, 1998.

Common Name	Scientific Name	Number Collected
Red Shiner	*Cyprinella lutrensis*	23
Bluntnose Minnow	*Pimephales notatus*	3
Common Shiner	*Luxilus cornutus*	1
Golden Shiner	*Notemigonus crysoleucas*	1
Creek Chub	*Semotilus atromaculatus*	1
Green Sunfish	*Lepomis cyanellus*	3
Bluegill	*Lepomis macrochirus*	1
Ozark Logperch	*Percina caprodes*	5

Table E - 8. Fish sampled from the East Fork Crooked River (site RAH 98-8) in the Crooked River basin on May 21, 1998.

Common Name	Scientific Name	Number Collected
Central Stoneroller	*Campostoma pullum*	43
Red Shiner	*Cyprinella lutrensis*	12
Common Shiner	*Luxilus cornutus*	60
Bigmouth Shiner	*Notropis dorsalis*	41
Sand Shiner	*Notropis ludibundus*	16
Suckermouth Minnow	*Phenacobius mirabilis*	6
Bluntnose Minnow	*Pimephales notatus*	11
Creek Chub	*Semotilus atromaculatus*	20
White Sucker	*Catostomus commersoni*	1
Yellow Bullhead	*Ameiurus natalis*	4
Green Sunfish	*Lepomis cyanellus*	23
Orangethroat Darter	*Etheostoma spectabile*	2

Table E - 9. Fish sampled from Unnamed Tributary #8 (site RAH 98-9) in the Crooked River basin on May 21, 1998.

Common Name	Scientific Name	Number Collected
Central Stoneroller	*Campostoma pullum*	72
Red Shiner	*Cyprinella lutrensis*	132
Common Shiner	*Luxilus cornutus*	70
Western Redfin Shiner	*Lythrurus u. umbratilis*	5
Bigmouth Shiner	*Notropis dorsalis*	125
Sand Shiner	*Notropis ludibundus*	29
Suckermouth Minnow	*Phenacobius mirabilis*	2
Bluntnose Minnow	*Pimephales notatus*	61
Fathead Minnow	*Pimephales promelas*	14
Creek Chub	*Semotilus atromaculatus*	19
White Sucker	*Catostomus commersoni*	5
Yellow Bullhead	*Ameiurus natalis*	2
Green Sunfish	*Lepomis cyanellus*	14
Largemouth Bass	*Micropterus salmoides*	1
Johnny Darter	*Etheostoma nigrum*	7
Orangethroat Darter	*Etheostoma spectabile*	23

Table E - 10. Fish sampled from the Fire Branch (site RAH 98-10) in the Crooked River basin on May 21, 1998.

Common Name	Scientific Name	Number Collected
Central Stoneroller	*Campostoma pullum*	24
Common Shiner	*Luxilus cornutus*	7
Bigmouth Shiner	*Notropis dorsalis*	36
Creek Chub	*Semotilus atromaculatus*	33
White Sucker	*Catostomus commersoni*	1
Black Bullhead	*Ameiurus melas*	7
Green Sunfish	*Lepomis cyanellus*	9
Bluegill	*Lepomis macrochirus*	2
Orangethroat Darter	*Etheostoma spectabile*	4

Table E - 11. Fish sampled from the Fire Branch (site RAH 98-11) in the Crooked River basin on May 21, 1998.

Common Name	Scientific Name	Number Collected
Central Stoneroller	*Campostoma pullum*	6
Red Shiner	*Cyprinella lutrensis*	78
Common Carp	*Cyprinus carpio*	1
Western Redfin Shiner	*Lythrurus u. umbratilis*	13
Common Shiner	*Luxilus cornutus*	65
Golden Shiner	*Notemigonus crysoleucas*	17
Bigmouth Shiner	*Notropis dorsalis*	6
Sand Shiner	*Notropis ludibundus*	15
Bluntnose Shiner	*Pimephales notatus*	48
Fathead Minnow	*Pimephales promelas*	5
Creek Chub	*Semotilus atromaculatus*	17
White Sucker	*Catostomus commersoni*	3
Green Sunfish	*Lepomis cyanellus*	2
Bluegill	*Lepomis macrochirus*	3

Table E-12. Fish sampled from the mainstem Crooked River (site RAH 98-12) in the Crooked River basin on May 21, 1998.

Common Name	Scientific Name	Number Collected
Central Stoneroller	*Campostoma pullum*	3
Red Shiner	*Cyprinella lutrensis*	34
Common Shiner	*Luxilus cornutus*	2
Bigmouth Shiner	*Notropis ludibundus*	3
Bluntnose Minnow	*Pimephales notatus*	5
Channel Catfish	*Ictalurus punctatus*	1
Green Sunfish	*Lepomis cyanellus*	2
Orangethroat Darter	*Etheostoma spectabile*	6
Ozark Logperch	*Percina caprodes*	2

Table E - 13. Fish sampled from the mainstem Crooked River (site RAH 98-13) in the Crooked River basin on May 21, 1998.

Common Name	Scientific Name	Number Collected
Central Stoneroller	*Campostoma pullum*	2
Red Shiner	*Cyprinella lutrensis*	263
Common Shiner	*Luxilus cornutus*	9
Bigmouth Shiner	*Notropis dorsalis*	15
Sand Shiner	*Notropis ludibundus*	26
Bluntnose Shiner	*Pimephales notatus*	105
Creek Chub	*Semotilus atromaculatus*	14
White Sucker	*Catostomus commersoni*	1
Yellow Bullhead	*Ameiurus natalis*	2
Green Sunfish	*Lepomis cyanellus*	4

Table E - 14. Fish sampled from Unnamed Tributary #5 (site RAH 98-14) in the Crooked River basin on June 4, 1998.

Common Name	Scientific Name	Number Collected
Central Stoneroller	*Campostoma pullum*	54
Common Shiner	*Luxilus cornutus*	84
Bigmouth Shiner	*Notropis dorsalis*	122
Sand Shiner	*Notropis ludibundus*	37
Suckermouth Minnow	*Phenacobius mirabilis*	1
Bluntnose Minnow	*Pimephales notatus*	31
Creek Chub	*Semotilus atromaculatus*	43
White Sucker	*Catostomus commersoni*	2
Green Sunfish	*Lepomis cyanellus*	7
Johnny Darter	*Etheostoma nigrum*	3
Orangethroat Darter	*Etheostoma spectabile*	5

Table E - 15. Fish sampled from East Fork Crooked River (site RAH 98-16) in the Crooked River basin on June 4, 1998.

Common Name	Scientific Name	Number Collected
Central Stoneroller	*Campostoma pullum*	34
Red Shiner	*Cyprinella lutrensis*	172
Common Shiner	*Luxilus cornutus*	56
Western Redfin Shiner	*Lythrurus u. umbratilis*	91
Bigmouth Shiner	*Notropis dorsalis*	9
Sand Shiner	*Notropis ludibundus*	3
Bluntnose Minnow	*Pimephales notatus*	25
Fathead Minnow	*Pimephales promelas*	2
Creek Chub	*Semotilus atromaculatus*	25
White Sucker	*Catostomus commersoni*	1
Green Sunfish	*Lepomis cyanellus*	1
Johnny Darter	*Etheostoma nigrum*	5
Orangethroat Darter	*Etheostoma spectabile*	22

Table E - 16. Fish sampled from East Fork Crooked River (site RAH 98-17) in the Crooked River basin on June 4, 1998.

Common Name	Scientific Name	Number Collected
Central Stoneroller	*Campostoma pullum*	67
Red Shiner	*Cyprinella lutrensis*	22
Common Shiner	*Luxilus cornutus*	50
Bigmouth Shiner	*Notropis dorsalis*	7
Bluntnose Minnow	*Pimephales notatus*	18
Fathead Minnow	*Pimephales promelas*	4
Creek Chub	*Semotilus atromaculatus*	23
White Sucker	*Catostomus commersoni*	16
Green Sunfish	*Lepomis cyanellus*	11
Bluegill	*Lepomis macrochirus*	8
Johnny Darter	*Etheostoma nigrum*	10
Orangethroat Darter	*Etheostoma spectabile*	7

Table E - 17. Fish sampled from Unnamed Tributary #8 (site RAH 98-18) in the Crooked River basin on June 4, 1998.

Common Name	Scientific Name	Number Collected
Central Stoneroller	*Campostoma pullum*	49
Red Shiner	*Cyprinella lutrensis*	86
Bigmouth Shiner	*Notropis dorsalis*	3
Sand Shiner	*Notropis ludibundus*	2
Creek Chub	*Semotilus atromaculatus*	31
White Sucker	*Catostomus commersoni*	2
Black Bullhead	*Ameiurus melas*	1
Green Sunfish	*Lepomis cyanellus*	16
Bluegill	*Lepomis macrochirus*	1
Black Crappie	*Pomoxis nigromaculatus*	1

Table E - 18. Fish sampled from Crooked River (site RAH 98-19) in the Crooked River basin on June 4, 1998.

Common Name	Scientific Name	Number Collected
Central Stoneroller	*Campostoma pullum*	11
Red Shiner	*Cyprinella lutrensis*	333
Common Shiner	*Luxilus cornutus*	58
Western Redfin Shiner	*Lythrurus u. umbratilis*	72
Bigmouth Shiner	*Notropis dorsalis*	25
Sand Shiner	*Notropis ludibundus*	18
Suckermouth Minnow	*Phenacobius mirabilis*	18
Bluntnose Minnow	*Pimephales notatus*	9
Creek Chub	*Semotilus atromaculatus*	10
White Sucker	*Catostomus commersoni*	4
Green Sunfish	*Lepomis cyanellus*	5
Orangespotted Sunfish	*Lepomis humilis*	2
Johnny Darter	*Etheostoma nigrum*	22
Orangethroat Darter	*Etheostoma spectabile*	22

Table E - 19. Fish sampled from Brushy Creek (site RAH 98-20) in the Crooked River basin on June 4, 1998.

Common Name	Scientific Name	Number Collected
Central Stoneroller	*Campostoma pullum*	79
Red Shiner	*Cyprinella lutrensis*	254
Common Shiner	*Luxilus cornutus*	123
Western Redfin Shiner	*Lythrurus u. umbratilis*	39
Bigmouth Shiner	*Notropis dorsalis*	102
Sand Shiner	*Notropis ludibundus*	49
Suckermouth Minnow	*Phenacobius mirabilis*	29
Bluntnose Minnow	*Pimephales notatus*	76
Fathead Minnow	*Pimephales promelas*	1
Creek Chub	*Semotilus atromaculatus*	38
White Sucker	*Catostomus commersoni*	18
Yellow Bullhead	*Ameiurus natalis*	2
Green Sunfish	*Lepomis cyanellus*	7
Orangespotted Sunfish	*Lepomis humilis*	1
Bluegill	*Lepomis macrochirus*	2
Johnny Darter	*Etheostoma nigrum*	2
Orangethroat Darter	*Etheostoma spectabile*	7
Ozark Logperch	*Percina caprodes*	1

Table E - 20. Fish sampled from Brushy Creek (site RAH 98-21) in the Crooked River basin on June 4, 1998.

Common Name	Scientific Name	Number Collected
Red Shiner	*Cyprinella lutrensis*	211
Common Shiner	*Luxilus cornutus*	34
Bigmouth Shiner	*Notropis dorsalis*	10
Bluntnose Minnow	*Pimephales notatus*	1
Creek Chub	*Semotilus atromaculatus*	10
Black Bullhead	*Ameiurus melas*	3
Green Sunfish	*Lepomis cyanellus*	16

Table E - 21. Fish sampled in the Crooked River, 6 miles upstream of the Missouri River, August 1941, Location: 0942A, UTM x - 425700/y - 4347500 (MDC Files).

Common Name	Scientific Name
Shortnose Gar	*Lepisosteus platostomus*
Gizzard Shad	*Dorosoma cepedianum*
Red Shiner	*Cyprinella lutrensis*
Common Carp	*Cyprinus carpio*
Emerald Shiner	*Notropis atherinoides*
Fathead Minnow	*Pimephales promelas*
Smallmouth Buffalo	*Ictiobus bubalus*
Black Bullhead	*Ameiurus melas*
Yellow Bullhead	*Ameiurus natalis*
Orangespotted Sunfish	*Lepomis humilis*

Table E - 22. Fish sampled in the Crooked River, 29 miles upstream of Missouri River, August 1965, Location: 1364B, UTM x - 410200/y - 4358500 (MDC Files).

Common Name	Scientific Name
Red Shiner	*Cyprinella lutrensis*
Common Carp	*Cyprinus carpio*
Common Shiner	*Luxilus cornutus*
Western Redfin Shiner	*Lythrurus u. umbratilis*
Bigmouth Shiner	*Notropis dorsalis*
Sand Shiner	*Notropis ludibundus*
Bluntnose Minnow	*Pimephales notatus*
Fathead Minnow	*Pimephales promelas*
Creek Chub	*Semotilus atromaculatus*
White Sucker	*Catostomus commersoni*
Black Bullhead	*Ameiurus melas*
Channel Catfish	*Ictalurus punctatus*
Green Sunfish	*Lepomis cyanellus*
Orangespotted Sunfish	*Lepomis humilis*
White Crappie	*Pomoxis annularis*

Table E - 23. Fish sampled in the Crooked River, 59 miles upstream of Missouri River, September 1965, Location: 1363B, UTM x - 398600/y - 4378300 (MDC Files).

Common Name	Scientific Name
Central Stoneroller	*Campostoma pullum*
Red Shiner	*Cyprinella lutrensis*
Common Shiner	*Luxilus cornutus*
Western Redfin Shiner	*Lythrurus u. umbratilis*
Bigmouth Shiner	*Notropis dorsalis*
Sand Shiner	*Notropis ludibundus*
Topeka Shiner	*Notropis topeka*
Suckermouth Minnow	*Phenacobius mirabilis*
Bluntnose Minnow	*Pimephales notatus*
Fathead Minnow	*Pimephales promelas*
Creek Chub	*Semotilus atromaculatus*
River Carpsucker	*Carpiodes carpio*
Black Bullhead	*Ameiurus melas*
Green Sunfish	*Lepomis cyanellus*
Orangespotted Sunfish	*Lepomis humilis*
Bluegill	*Lepomis macrochirus*
Johnny Darter	*Etheostoma nigrum*
Orangethroat Darter	*Etheostoma spectabile*

Table E - 24. Fish sampled in the East Fork Crooked River, 5 miles upstream of its confluence with Crooked River, August 1965 Location: 1366B, UTM x - 423200/y - 4354000 (MDC Files).

Common Name	Scientific Name
Gizzard Shad	*Dorosoma cepedianum*
Central Stoneroller	*Campostoma pullum*
Red Shiner	*Cyprinella lutrensis*
Common Carp	*Cyprinus carpio*
Common Shiner	*Luxilus cornutus*
Western Redfin Shiner	*Lythrurus u. umbratilis*
Bigmouth Shiner	*Notropis dorsalis*
Sand Shiner	*Notropis ludibundus*
Suckermouth Minnow	*Phenacobius mirabilis*
Bluntnose Minnow	*Pimephales notatus*
Fathead Minnow	*Pimephales promelas*
Creek Chub	*Semotilus atromaculatus*
River Carpsucker	*Carpiodes carpio*
White Sucker	*Catostomus commersoni*
Black Bullhead	*Ameiurus melas*
Green Sunfish	*Lepomis cyanellus*
Orangespotted sunfish	*Lepomis humilis*
Bluegill	*Lepomis macrochirus*
Largemouth Bass	*Micropterus salmoides*
White Crappie	*Pomoxis annularis*
Orangethroat Darter	*Etheostoma spectabile*

Table E - 25. Fish sampled in the Rocky Fork, one mile upstream of its confluence with the Crooked River, August 1965 Location: 1365B, UTM x - 409900 / y - 4358300 (MDC Files).

Common Name	Scientific Name
Central Stoneroller	*Campostoma pullum*
Red Shiner	*Cyprinella lutrensis*
Common Shiner	*Luxilus cornutus*
Western Redfin Shiner	*Lythrurus u. umbratilis*
Bigmouth Shiner	*Notropis dorsalis*
Sand Shiner	*Notropis ludibundus*
Bluntnose Minnow	*Pimephales notatus*
Fathead Minnow	*Pimephales promelas*
Creek Chub	*Semotilus atromaculatus*
Johnny Darter	*Etheostoma nigrum*
Orangethroat Darter	*Etheostoma spectabile*

Table E - 26. Fish sampled in the Crooked River, 59 miles upstream of Missouri River, June 1995, Location: 1363G, UTM x - 398600/y - 4378300 (MDC Files).

Common Name	Scientific Name
Central Stoneroller	*Campostoma pullum*
Red Shiner	*Cyprinella lutrensis*
Common Shiner	*Luxilus cornutus*
Western Redfin Shiner	*Lythrurus u. umbratilis*
Bigmouth Shiner	*Notropis dorsalis*
Sand Shiner	*Notropis ludibundus*
Suckermouth Minnow	*Phenacobius mirabilis*
Bluntnose Minnow	*Pimephales notatus*
Creek Chub	*Semotilus atromaculatus*
River Carpsucker	*Carpiodes carpio*
White Sucker	*Catostomus commersoni*
Channel Catfish	*Ictalurus punctatus*
Green Sunfish	*Lepomis cyanellus*
Orangespotted sunfish	*Lepomis humilis*
Bluegill	*Lepomis macrochirus*
Largemouth Bass	*Micropterus salmoides*
White Crappie	*Pomoxis annularis*
Johnny Darter	*Etheostoma nigrum*
Orangethroat Darter	*Etheostoma spectabile*

Table E - 27. Fish sampled in a Tributary to the East Fork Crooked River, June 1995, Location: 2397G, UTM x - 412900/y - 4376900 (MDC Files).

Common Name	Scientific Name
Central Stoneroller	*Campostoma pullum*
Red Shiner	*Cyprinella lutrensis*
Common Shiner	*Luxilus cornutus*
Golden Shiner	*Notemigonus crysoleucas*
Bigmouth Shiner	*Notropis dorsalis*
Sand Shiner	*Notropis ludibundus*
Creek Chub	*Semotilus atromaculatus*
White Sucker	*Catostomus commersoni*
Green Sunfish	*Lepomis cyanellus*
Bluegill	*Lepomis macrochirus*
Black Crappie	*Pomoxis nigromaculatus*

Table E - 28. Fish sampled in the East Fork Crooked River 30 miles upstream of its confluence with the Crooked River, June 1995, Location: 2398G, UTM x - 416900/y - 4378400 (MDC files).

Common Name	Scientific Name
Central Stoneroller	*Campostoma pullum*
Red Shiner	*Cyprinella lutrensis*
Common Shiner	*Luxilus cornutus*
Western Redfin Shiner	*Lythrurus u. umbratilis*
Bigmouth Shiner	*Notropis dorsalis*
Fathead Minnow	*Pimephales promelas*
Creek Chub	*Semotilus atromaculatus*
White Sucker	*Catostomus commersoni*
Green Sunfish	*Lepomis cyanellus*
Bluegill	*Lepomis macrochirus*
Johnny Darter	*Etheostoma nigrum*
Orangethroat Darter	*Etheostoma*

Table E - 29. Fish sampled in the Crooked River, 63 miles upstream of its confluence with the Missouri River, June 1995, Location: 2407G, UTM x - 395300/y - 4377700 (MDC files).

Common Name	Scientific Name
Central Stoneroller	*Campostoma pullum*
Red Shiner	*Cyprinella lutrensis*
Common Shiner	*Luxilus cornutus*
Western Redfin Shiner	*Lythrurus u. umbratilis*
Bigmouth Shiner	*Notropis dorsalis*
Sand Shiner	*Notropis ludibundus*
Suckermouth Minnow	*Phenacobius mirabilis*
Bluntnose Minnow	*Pimephales notatus*
Fathead Minnow	*Pimephales promelas*
Creek Chub	*Semotilus atromaculatus*
White Sucker	*Catostomus commersoni*
Green Sunfish	*Lepomis cyanellus*
Orangespotted sunfish	*Lepomis humilis*
Bluegill	*Lepomis macrochirus*
Largemouth Bass	*Micropterus salmoides*
Johnny Darter	*Etheostoma nigrum*
Orangethroat Darter	*Etheostoma spectabile*

Table E - 30. Fish sampled in the Crooked River, 65 miles upstream of its confluence with the Missouri River, June 1995, Location: 2408G, UTM x - 392500/y - 4375900 (MDC files).

Common Name	Scientific Name
White Sucker	*Catostomus commersoni*
Black Bullhead	*Ameiurus melas*

Table E - 31. Fish sampled in Unnamed #08, a tributary of the East Fork Crooked River, June 1995, Location: 2413G, UTM x - 416300/y - 4367400 (MDC files).

Common Name	Scientific Name
Central Stoneroller	*Campostoma pullum*
Red Shiner	*Cyprinella lutrensis*
Common Shiner	*Luxilus cornutus*
Western Redfin Shiner	*Lythrurus u. umbratilis*
Bigmouth Shiner	*Notropis dorsalis*
Sand Shiner	*Notropis ludibundus*
Suckermouth Minnow	*Phenacobius mirabilis*
Bluntnose Minnow	*Pimephales notatus*
Fathead Minnow	*Pimephales promelas*
Creek Chub	*Semotilus atromaculatus*
White Sucker	*Catostomus commersoni*
Green Sunfish	*Lepomis cyanellus*
Bluegill	*Lepomis macrochirus*
Johnny Darter	*Etheostoma nigrum*
Orangethroat Darter	*Etheostoma spectabile*

Table E - 32. Fish sampled in East Fork Crooked River, 22 miles upstream of its confluence with Crooked River, June 1995, Location: 2414G, UTM x - 418200/y - 4370200 (MDC files).

Common Name	Scientific Name
Central Stoneroller	*Campostoma pullum*
Red Shiner	*Cyprinella lutrensis*
Common Shiner	*Luxilus cornutus*
Western Redfin Shiner	*Lythrurus u. umbratilis*
Bigmouth Shiner	*Notropis dorsalis*
Sand Shiner	*Notropis ludibundus*
Suckermouth Minnow	*Phenacobius mirabilis*
Bluntnose Minnow	*Pimephales notatus*
Fathead Minnow	*Pimephales promelas*
Creek Chub	*Semotilus atromaculatus*
White Sucker	*Catostomus commersoni*
Green Sunfish	*Lepomis cyanellus*
Bluegill	*Lepomis macrochirus*
Johnny Darter	*Etheostoma nigrum*
Orangethroat Darter	*Etheostoma spectabile*
Ozark Logperch	*Percina caprodes*

Table E - 33. Fish sampled in the West Fork Crooked River, 11 miles upstream of its confluence with the Crooked River, June 1995, Location: 2415G, UTM x - 409600/y - 4348600 (MDC files).

Common Name	Scientific Name
Central Stoneroller	*Campostoma pullum*
Red Shiner	*Cyprinella lutrensis*
Common Shiner	*Luxilus cornutus*
Western Redfin Shiner	*Lythrurus u. umbratilis*
Bigmouth Shiner	*Notropis dorsalis*
Sand Shiner	*Notropis ludibundus*
Suckermouth Minnow	*Phenacobius mirabilis*
Bluntnose Minnow	*Pimephales notatus*
Creek Chub	*Semotilus atromaculatus*
White Sucker	*Catostomus commersoni*
Green Sunfish	*Lepomis cyanellus*
Bluegill	*Lepomis macrochirus*
Orangethroat Darter	*Etheostoma spectabile*

Table E - 34. Fish sampled in a tributary of the West Fork Crooked River, June 1995, Location: 2416G, UTM x - 402600/y - 4355500 (MDC Files).

Common Name	Scientific Name
Central Stoneroller	*Campostoma pullum*
Red Shiner	*Cyprinella lutrensis*
Common Shiner	*Luxilus cornutus*
Golden Shiner	*Notemigonus crysoleucas*
Bluntnose Minnow	*Pimephales notatus*
Creek Chub	*Semotilus atromaculatus*
White Sucker	*Catostomus commersoni*
Green Sunfish	*Lepomis cyanellus*
Bluegill	*Lepomis macrochirus*
Orangethroat Darter	*Etheostoma spectabile*

Table E -35. Fish sampled in the West Fork Crooked River, 18 miles upstream of its confluence with the Crooked River, June 1995, Location: 2417G, UTM x - 404900/y - 4355700 (MDC files).

Common Name	Scientific Name
Bluntnose Minnow	*Pimephales notatus*

Table E - 36. Fish sampled in the West Fork Crooked River, 17 miles upstream of its confluence with the Crooked River, June 1995, Location: 2418G, UTM x - 405300/y - 4354400 (MDC files).

Common Name	Scientific Name
Central Stoneroller	*Campostoma pullum*
Red Shiner	*Cyprinella lutrensis*
Common Shiner	*Luxilus cornutus*
Western Redfin Shiner	*Lythrurus u. umbratilis*
Golden Shiner	*Notemigonus crysoleucas*
Bigmouth Shiner	*Notropis dorsalis*
Sand Shiner	*Notropis ludibundus*
Bluntnose Minnow	*Pimephales notatus*
Fathead Minnow	*Pimephales promelas*
Creek Chub	*Semotilus atromaculatus*
White Sucker	*Catostomus commersoni*
Black Bullhead	*Ameiurus melas*
Green Sunfish	*Lepomis cyanellus*
Bluegill	*Lepomis macrochirus*
Orangethroat Darter	*Etheostoma spectabile*

Table E - 37. Fish sampled in the Rocky Fork, 3 miles upstream of its confluence with the Crooked River, July 1995, Location: 2419G, UTM x - 507700/y - 4358700 (MDC files).

Common Name	Scientific Name
Central Stoneroller	*Campostoma pullum*
Red Shiner	*Cyprinella lutrensis*
Common Shiner	*Luxilus cornutus*
Western Redfin Shiner	*Lythrurus u. umbratilis*
Bigmouth Shiner	*Notropis dorsalis*
Sand Shiner	*Notropis ludibundus*
Bluntnose Minnow	*Pimephales notatus*
Creek Chub	*Semotilus atromaculatus*
White Sucker	*Catostomus commersoni*
Black Bullhead	*Ameiurus melas*
Green Sunfish	*Lepomis cyanellus*
Bluegill	*Lepomis macrochirus*
Largemouth Bass	*Micropterus salmoides*
Johnny Darter	*Etheostoma nigrum*
Orangethroat Darter	*Etheostoma spectabile*

Table E - 38. Fish sampled in the Rocky Fork, 7 miles upstream of its confluence with the Crooked River, June 1995, Location: 2420G, UTM x - 404400/y - 4359500 (MDC files).

Common Name	Scientific Name
Green Sunfish	*Lepomis cyanellus*

Table E - 39. Fish sampled in the Rocky Fork, 10 miles upstream of its confluence with the Crooked River, June 1995, Location: 2421G, UTM x - 400900/y - 4363900 (MDC files).

Common Name	Scientific Name
Central Stoneroller	*Campostoma pullum*
Creek Chub	*Semotilus atromaculatus*
Bluegill	*Lepomis macrochirus*

Appendix F. Aquatic invertebrates collected in the Crooked River basin.

Table F-1 . Stream: Crooked River at MDC Morton Bridge Access, Ray County, Missouri. Location: UTM-X 422800 UTM-Y 4349700. Date: September 21, 1987. Samples collected using three Hester Dendy samplers. (Steve Eder, MDC files).

Phylum	Class	Order	Family	Scientific Name	Number
Annelida					23
	Oligochaeta				27
	Hirudinea				2
Mollusca	Gastropoda	Lymnophila	Physidae	*Physella sp.*	4
	Bivalvia	Pelecypoda			1
			Sphaeriidae		13
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Stenacron sp.*	24
			Caenidae	*Caenis sp.*	6
			Ephemeridae	*Hexagenia sp.*	3
		Odonata	Coenagrionidae	*Argia sp.*	83
			Coenagrionidae	*Enallagma sp.*	1
		Hemiptera	Corixidae		1
			Corixidae	*Palmocorixa buenoi*	1
		Megaloptera	Sialidae	*Sialis sp.*	2
		Coleoptera	Elmidae	*Dubiraphia sp.*	18
		Trichoptera	Psychomyiidae/ Polycentropodidae	*Polycentropus sp.*	7
			Polycentropodinae	*Nyctiophylax sp.*	4
			Hydropsychidae	*Cheumatopsyche sp.*	4
		Diptera	Chironomidae		64
			Ceratopogonidae		1
			Chaoboridae	*Chaoborus sp.*	1

Table F-2. Stream: Crooked River near Elmira, Ray County Missouri. Location: UTM-X 401300 UTM-Y 4373800. Date: September 21, 1987. Samples collected using three Hester Dendy samplers. (Steve Eder, MDC files).

Phylum	Class	Order	Family	Scientific Name	Number
Annelida					3
Mollusca	Gastropoda	Lymnophila	Physidae	*Physella sp.*	22
	Bivalvia	Pelecypoda	Sphaeriidae		1
Arthropoda	Crustacea	Decapoda	Astacidae	*Orconectes virilis*	4
	Insecta	Ephemeroptera	Heptageniidae	*Stenacron sp.*	78
			Heptageniidae	*Stenonema sp.*	14
			Heptageniidae	*Stenonema femoratum*	5
			Caenidae	*Caenis sp.*	137
			Tricorythidae	*Tricorythodes sp.*	1
			Ephemeridae	*Hexagenia sp.*	12
		Odonata	Coenagrionidae	*Argia sp.*	147
			Coenagrionidae	*Enallagma sp.*	3
		Coleoptera	Hydrophilidae	*Berosus sp.*	1
			Elmidae	*Dubiraphia sp.*	4
			Elmidae	*Stenelmis beameri*	1
		Trichoptera	Psychomyiidae/ Polycentropodidae	*Polycentropus sp.*	6
			Polycentropodinae	*Nyctiophylax sp.*	6
		Diptera	Chironomidae		165
			Ceratopogonidae		1

Table F - 3. Stream: Crooked River near Elmira, Missouri (Ray County) Location: UTM-X 401300 UTM-Y 4373800 Date: September 21, 1987 Samples collected using a Surber Sampler (three samples combined). (Steve Eder, MDC files).

Phylum	Class	Order	Family	Scientific Name	Number
Annelida					3
Mollusca	Gastropoda	Lymnophila	Physidae	*Physella sp.*	22
	Bivalvia	Pelecypoda	Sphaeriidae		1
Arthropoda	Crustacea	Decapoda	Astacidae	*Orconectes virilis*	4
	Insecta	Ephemeroptera	Heptageniidae	*Stenacron sp.*	78
			Heptageniidae	*Stenonema sp.*	14
			Heptageniidae	*Stenonema femoratum*	5
			Caenidae	*Caenis sp.*	137
			Tricorythidae	*Tricorythodes sp.*	1
			Ephemeridae	*Hexagenia sp.*	12
		Odonata	Coenagrionidae	*Argia sp.*	147
			Coenagrionidae	*Enallagma sp.*	3
		Coleoptera	Hydrophilidae	*Berosus sp.*	1
			Elmidae	*Dubiraphia sp.*	4
			Elmidae	*Stenelmis beameri*	1
		Trichoptera	Psychomyiidae/ Polycentropodidae	*Polycentropus sp.*	6
			Polycentropodinae	*Nyctiophylax sp.*	6
		Diptera	Chironomidae		165
			Ceratopogonidae		1

Table F - 4. Stream: Crooked River at Crooked River Conservation Area, Ray County, Missouri. Location: UTM-X 408900 UTM-Y 4362800 Date: September 21, 1987. Samples collected using three Hester Dendy samplers. (Steve Eder, MDC files).

Phylum	Class	Order	Family	Scientific Name	Number
Annelida					12
	Oligochaeta				92
Mollusca	Gastropoda	Lymnophila	Lymnaeidae	*Lymnaea sp.*	2
			Physidae	*Physella sp.*	14
			Planorbidae		9
	Bivalvia	Pelecypoda			1
			Sphaeriidae		5
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Stenacron sp.*	50
			Caenidae	*Caenis sp.*	15
			Ephemeridae	*Hexagenia sp.*	3
		Odonata	Coenagrionidae	*Argia sp.*	312
			Coenagrionidae	*Enallagma sp.*	1
		Hemiptera	Corixidae		2
		Megaloptera	Sialidae	*Sialis sp.*	22
			Corydalidae	*Corydalus sp.*	2
		Coleoptera	Elmidae	*Dubiraphia sp.*	26
		Trichoptera	Psychomyiidae/ Polycentropodidae	*Polycentropus sp.*	1
			Polycentropodinae	*Nyctiophylax sp.*	1
			Hydropsychidae	*Cheumatopsyche sp.*	5
		Diptera	Chironomidae		131
			Ceratopogonidae		1

Table F -5. Stream: Crooked River at Crooked River Conservation Area, Ray County, Missouri. Location: UTM-X 408900 UTM-Y 4362800 Date: September 21, 1987 Sample collected using a Surber Sampler. (Steve Eder, MDC files).

Phylum	Class	Order	Family	Scientific Name	Number
Annelida					12
	Oligochaeta				1
Mollusca	Gastropoda	Lymnophila	Lymnaeidae	*Lymnaea sp.*	1
			Planorbidae		2
	Bivalvia	Pelecypoda	Sphaeriidae		62
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis sp.*	9
			Heptageniidae	*Stenacron sp.*	5
			Heptageniidae	*Stenonema sp.*	1
			Caenidae	*Caenis sp.*	11
			Tricorythidae	*Tricorythodes sp.*	13
		Odonata	Coenagrionidae	*Argia sp.*	1
		Megaloptera	Corydalidae	*Corydalis cornutus*	2
		Coleoptera	Dryopidae	*Helichus lithophilus*	3
			Elmidae	*Dubiraphia sp.*	2
			Elmidae	*Stenelmis sp. (larvae)*	33
			Elmidae	*Stenelmis crenata?*	3
			Elmidae	*Stenelmis sexlineata*	9
		Trichoptera	Philopotamidae	*Chimarra obscura*	1
			Hydropsychidae	*Cheumatopsyche sp.*	195
		Diptera	Chironomidae		26
			Simuliidae		3
			Tabanidae	*Chrysops sp.*	1

Table F - 6. Dragonflies found in the Crooked River basin (Linden Trial, MDC Files).

Area Name	Location (T-R-Sec)	Common Name	Scientific Name	Date
Taylor Roadside Park	52N-28W- 1	Clubtail	*Gomphidae*	Jul-97
Foxglove CA	53N-29W-23	Halloween Pennant	*Celithemis eponina*	Jul-97
		Calico Pennant	*Celithemis elisa*	
		Eastern Amberwing	*Perithemis tenera*	
		Pied Skimmer	*Libellula luctuosa*	
		Twelve Spotted Skimmer	*Libellula pulchella*	
		Darner	*Aeshnidae*	
		Green Darner	*Anax junius*	
		Glider	*Tramea sp.*	
Blue Jay Trail Access	54N-29W-25	Ebony Jewelwing	*Calopteryx maculata*	Jul-97
		American Rubyspot	*Hetaerina americana*	
		Common Whitetail	*Libellula lydia*	
		Pied Skimmer	*Libellula luctuosa*	
		Twelve Spotted Skimmer	*Libellula pulchella*	
		Eastern Pondhawk	*Erythemus simplicicollis*	
		Clubtail	*Gomphidae*	
Blue Jay Trail Access	54N-29W-25	River Cruiser	*Macromia sp.*	Sep. 1997
Crooked River CA	53N-28W-16	Ebony Jewelwing	*Calopteryx maculata*	Jul-97
		Eastern Pondhawk	*Erythemus simplicicollis*	
		Common Whitetail	*Libellula lydia*	
		Pied Skimmer	*Libellula luctuosa*	
		Twelve Spotted Skimmer	*Libellula pulchella*	

Area Name	Location (T-R-Sec)	Common Name	Scientific Name	Date
		Blue Dasher	*Pachydiplax longipennis*	
		Sanddragon	*Progomphus sp.*	
		Violet-masked Glider	*Tramea carolina*	
		Black Mantled Glider	*Tramea lacerata*	
		Darner	*Aeshnidae*	
Crooked River CA	53N-28W-16	Clubtail	*Gomphidae*	Jul-97
Crooked River CA	53N-28W-16	Green Darner	*Anax junius*	Sep.1997
		Globe Glider	*Pantala flavescens*	
		Black Mantled Glider	*Tramea lacerata*	
	53N-28W- 8	Green Darner	*Anax junius*	Sep. 1997
		Pied Skimmer	*Libellula luctuosa*	
		Meadowfly	*Sympetrum sp.*	
		Black Mantled Glider	*Tramea lacerata*	

Table 6. Crayfish whose range includes the Crooked River basin (Pflieger 1996).

Common Name	Scientific Name	Collection
Devil Crayfish	*Cambarus diogenes*	Not documented
Papershell Crayfish	*Orconectes immunis*	Not Documented
Northern Crayfish	*Orconectes virilis*	1987 and 1998
Grassland Crayfish	*Procambarus gracilis*	Not documented

Table 7. Mussels collected in the Crooked River basin in 1997(MDC files).

Common Name	Scientific Name
Giant Floater	*Pyganodon grandis*
White Heelsplitter	*Lasmigona complanata*
Fragile Papershell	*Leptodea fragilis*
Pond Mussel	*Ligumia subrostrata*
Maple Leaf	*Quadrula quadrula*
Pondhorn	*Uniomerus tetralasmus*

Table 8. Amphibians found in the Crooked River basin (Johnson 1987).

Common Name	Scientific Name	Range
Smallmouth Salamander	*Ambystoma texanum*	basinwide
Eastern Tiger Salamander	*Ambystoma tigrinum tigrinum*	basinwide
Central Newt	*Notophthalmus viridescens louisianensis*	basinwide
Mudpuppy	*Necturus maculosus*	basinwide
Plains Spadefoot	*Scaphiopus bombifrons*	Missouri River floodplain
Eastern American Toad	*Bufo americanus*	basinwide
Great Plains Toad	*Bufo cognatus*	Missouri River floodplain
Woodhouse's Toad	*Bufo woodhousei woodhousei*	basinwide
Blanchard's Cricket Frog	*Acris crepitans blanchardi*	basinwide
Northern Spring Peeper	*Hyla crucifer crucifer*	basinwide
Cope's Gray Treefrog	*Hyla chrysoscelis*	basinwide
Eastern Gray Treefrog	*Hyla versicolor*	basinwide
Western Chorus Frog	*Pseudacris triserata*	basinwide
Great Plains Narrowmouth Toad	*Gastrophryne olivacea*	Missouri River floodplain
Northern Crawfish Frog	*Rana areolata circulosa*	basinwide
Plains Leopard Frog	*Rana blairi*	basinwide
Bullfrog	*Rana catesbeiana*	basinwide
Green Frog	*Rana clamitans*	basinwide
Southern Leopard Frog	*Rana sphenocephala*	basinwide

Table 9. Reptiles found in the Crooked River basin (Johnson 1987).

Common Name	Scientific Name	Area
Common Snapping Turtle	*Chelydra serpentina serpentina*	basinwide
Stinkpot	*Sternotherus odoratus*	basinwide
Western Painted Turtle	*Chrysemys picta bellii*	basinwide
Map Turtle	*Graptemys geographica*	basinwide
Mississippi Map Turtle	*Graptemys kohnii*	basinwide
False Map Turtle	*Graptemys pseudogeographica pseudogeographica*	basinwide
Three-toed Box Turtle	*Terrapene carolina triunguis*	basinwide
Ornate Box Turtle	*Terrapene ornata ornata*	basinwide
Red-eared Slider	*Trachemys scripta elegans*	basinwide
Midland Smooth Softshell	*Trionyx muticus muticus*	basinwide
Western Spiny Softshell	*Trionyx spinifer hartwegi*	basinwide
Five-lined Skink	*Eumeces fasciatus*	basinwide
Broadhead Skink	*Eumeces laticeps*	basinwide
Ground Skink	*Scincella lateralis*	basinwide
Prairie-lined Racerunner	*Cnemidophorus sexlineatus viridis*	basinwide
Western Slender Glass Lizard	*Ophisaurus attenuatus attenuatus*	basinwide
Western Worm Snake	*Carphophis amoenus vermis*	basinwide
Eastern Yellowbelly Racer	*Coluber constrictor flaviventris*	basinwide
Prairie Ringneck Snake	*Diadophis punctatus arnyi*	basinwide
Great Plains Rat Snake	*Elaphe guttata emoryi*	basinwide
Black Rat Snake	*Elaphe obsoleta obsoleta*	basinwide
Eastern Hognose	*Heterodon platyrhinos*	basinwide
Prarie Kingsnake	*Lampropeltis calligaster calligaster*	basinwide
Speckled Kingsnake	*Lampropeltis getulus holbrooki*	basinwide
Red Milk Snake	*Lampropeltis triangulum syspila*	basinwide
Blotched Water Snake	*Nerodia erythrogaster transversa*	basinwide
Diamondback Water Snake	*Nerodia rhombifer rhombifer*	basinwide

Common Name	Scientific Name	Area
Northern Water Snake	*Nerodia sipedon sipedon*	basinwide
Rough Green Snake	*Opheodrys aestivus*	basinwide
Bullsnake	*Pituophis melanoleucus sayi*	basinwide
Grahams Crayfish Snake	*Regina grahamii*	basinwide
Texas Brown Snake	*Storeria dekayi texana*	basinwide
Northern Redbelly Snake	*Storeria occipitomaculata occipitomaculata*	basinwide
Western Ribbon Snake	*Thamnophis proximus proximus*	basinwide
Western Plains Garter Snake	*Thamnophis radix haydenii*	basinwide
Red-sided Garter Snake	*Thamnophis sirtalis parietalis*	basinwide
Central Lined Snake	*Tropidoclonion lineatum annectens*	basinwide
Northern Lined Snake	*Tropidoclonion lineatum lineatum*	basinwide
Western Earth Snake	*Virginia valeriae elegans*	basinwide
Osage Copperhead	*Agkistrodon contortrix phaeogaster*	basinwide
Timber Rattlesnake	*Crotalus horridus*	basinwide

Table 10. Threatened and endangered species in the Crooked River basin (MDC 1998; USFWS 1999).

Common Name	Scientific Name	State Status	Federal Status
Auriculate false foxglove	*Agalinus auriculata*	Imperiled (S2)	
Greater prairie-chicken	*Tympanuchus cupido*	Critically imperiled (S1)	

Table 11. Fish stocked in the Crooked River basin by the Missouri Department of Conservation (MDC NW Region files).

Water Body	County	Species Stocked
Lawson City Reservoir	Ray	Channel Catfish
Ray County Community Lake	Ray	Black Bullhead, Brown Bullhead, Channel Catfish, and Largemouth Bass

Management Problems and Opportunities

The Crooked River basin WIA was developed to address objectives provided in the Missouri Department of Conservation (MDC) Strategic Plan, Fisheries Division Operational Plan (FY 1996-2000), Stream Areas Program Plan and the Stream Access Acquisition Plan. These plans indicate areas of future expanded resource management, public awareness and access needs. Major areas of concern in the Crooked River basin include: Water quality, riparian and aquatic habitat, aquatic communities and recreational use. All goals are of equal importance; however, objectives are listed in order of priority under each goal. This plan only includes those items that MDC can reasonably attain or influence during the next 25 years. Completion of these objectives will depend upon their status in overall Regional and Divisional priorities, as well as the availability of personnel and funds.

Goal 1: Improve water quality and maintain or improve water quantity in the Crooked River basin so that all streams are capable of supporting native aquatic communities.

Status: Streams within the Crooked River basin suffer from several water quality problems associated with point and non-point source pollution. Turbidity and sedimentation from erosion and organic runoff from livestock operations are non-point sources of pollution in the basin. Sewage effluent from waste water treatment facilities is the primary point source pollutant. The Conservation Reserve Program (CRP) has reduced the acreage of highly erodible soil that once was in row crop production. Year-to-year renewal of contracts has resulted in CRP acreage enrollment remaining at approximately the same level in the Crooked River basin. There is increased interest in construction of concentrated animal feeding operations that could result in an increase in livestock waste point source runoff.

Objective 1.1: Water quality standards are met in all streams within the basin.

Strategy: Enforcing existing state and federal water quality regulations will help reduce the number of violations that occur. Gathering water quality data within the basin will provide more information about stream health within the basin. This information can be used to provide justification for protection and increased enforcement.

- Review NPDES, 404 and other permits and provide recommendations so compliance with water quality standards are maintained within the basin.
- Collect fish for contaminant analysis for the Missouri Department of Health and cooperate in advising the fishing public on the effects of contaminant levels in fish within the basin.
- Cooperate with other state and federal agencies to investigate fish kill reports and other water quality related problems reported in the basin.
- Monitor water quality and insure compliance with discharge permits. Most of this work is under the jurisdiction of Missouri Department of Natural Resources, but with training, volunteer group such as Stream Teams could assist with water quality monitoring and be strong advocates for water quality throughout the basin.
- Inform the public of water quality problems (i.e., sedimentation, livestock runoff and sewage effluent) affecting streams in the basin through media and personal contacts, literature development and distribution, Stream Team promotion, and special or educational events such as National Hunting and Fishing Day.

Objective 1.2: Maintain base flows within the Crooked River basin at or above current levels within the constraints imposed by natural seasonal variations in precipitation.

Strategy: Work closely with agricultural agencies to address concerns related to adequate streamflows within the basin. Work with state and local governments on laws and regulations pertaining to

maintenance of base flows.

- Support the development of a Missouri water law that addresses the quantity of water in Missouri streams.
- Provide technical assistance for SALT and EARTH projects as requested by Soil and Water Conservation Districts so base flows can be maintained.
- Inform the public of water quantity problems affecting streams in the basin through media and personal contacts, literature development and distribution, Stream Team promotion and events such as local sport shows, National Hunting and Fishing Day, etc.
- Work with other agencies to reactivate PL-566 projects in the Crooked River basin.
- Work with USACOE on water plans that are developed to insure adequate water availability both qualitatively and quantitatively to sustain healthy fish, forest, and wildlife communities.

Goal 2: Improve or maintain riparian and aquatic habitats in the Crooked River basin.

Status: Channelization and levees negatively affect riparian and aquatic habitats through increased stream bed and bank erosion, sedimentation and by reducing wooded corridors, instream cover and pool/riffle habitat complexes. Due to past channelization, some stream channels have down-cut below the root systems of trees so the remaining trees provide little, if any, streambank stability. In addition, landowners in the basin are reluctant to restore 100 feet wide vegetated corridors along each streambank because of perceived losses in row crop acreage.

Objective 2.1: With the exception of very unique situations, eliminate channelization, re-channelization or levee construction projects within the Crooked River basin.

Strategy: Preventing future channel alterations will require a combination of watchdog activities that encourage enforcement of current laws and educational programs. If these activities work, the need for law enforcement action in the future will be reduced.

- Review all 404 and other permits within the basin and provide comments on these applications to reduce impacts of channelization and levee construction.
- Cooperate with MDC Outreach and Education Division in presenting materials related to stream ecology and effects of channelization to elementary and/or secondary schools within the basin.
- Continue working to resolve the conflict over water levels in the Crooked River cutoff.

Objective 2.2: Inform landowners within the Crooked River basin about good stream stewardship practices and the importance of riparian corridors. Efforts to maintain and improve riparian conditions should be concentrated along the mainstem Crooked River and streams in the upper two thirds of the basin, as the best habitat within the Crooked River basin is found in these areas. The entire basin above the Missouri River floodplain is unique in Northwest Missouri, since it is less modified by stream alteration than any other basin in the region.

Strategy: Advertising and promoting stream incentive programs, installing and maintaining demonstration projects and providing educational opportunities regarding stream stewardship will allow landowners to be more aware of the reasons and techniques for protecting streams. Promoting stream incentive programs for improving riparian habitats will likely encourage more landowners to participate.

- Cooperate with Farm Service Agency (FSA), Natural Resources Conservation Service (NRCS) and University Outreach and Extension personnel to promote cost share programs that include streambank and streambed stabilization, alternate watering sources, excluding livestock access, and establishing and maintaining adequate stream corridors.

- Provide recommendations to all landowners who request assistance and are willing to establish and maintain adequate stream corridors.
- Provide stream management workshops for NRCS and University Outreach and Extension staff every five years for those people who have responsibilities for agriculture programs within the Crooked River basin.
- Cooperate with NRCS and Soil and Water Conservation Districts to establish SALT, EARTH, and PL-566 projects within the basin.
- Establish stream management demonstration sites within the basin (including economics (soil saved = dollars saved + better productivity) as this encourages participation).
- Promote sound land management practices that enhance stream quality through landowner workshops and demonstration site tours within the basin.
- Cooperate with MDC Outreach and Education Division in using streams within the basin for aquatic education programs.
- Coordinate and cooperate with Stream Teams to conduct riparian corridor improvement projects (e.g. planting trees).

Goal 3: Maintain diverse and abundant populations of native aquatic organisms while supporting angler demands for quality fishing.

Status: A comprehensive survey of the fishes inhabiting the Crooked River basin is needed in unsampled or inadequately sampled streams. Several species of fish desirable to anglers are found in the basin. Channel catfish, carp and bullhead catfish are the most sought after species, but sufficient samples to assess their populations are lacking. Limited invertebrate sampling has been conducted on the mainstem Crooked River, but a comprehensive study throughout the basin has not been conducted.

Objective 3.1: Assess and maintain native non-game fish populations and aquatic invertebrates at or above present levels throughout the basin.

Strategy: Assess the status of fish and invertebrate communities throughout the basin through a cooperative effort between MDNR, MDC, and local universities. Achieving habitat objectives within the basin should ensure maintenance and improvement of aquatic communities. To determine if there are changes in aquatic communities within the basin, periodic surveys will need to be conducted with directed effort toward collecting indicator species within the basin.

- Develop standard sampling techniques for assessing fish and aquatic invertebrate communities, including use of indicator species.
- Identify critical habitats for indicator species at all life stages and maintain or enhance these areas as needed to stabilize and/or increase populations. Work to target or direct SALT, EARTH, etc. projects to include these areas.
- Implement a sampling program that monitors diversity and abundance of aquatic communities throughout the basin in cooperation with MDNR and local universities. Through training, Stream Teams could provide additional information on aquatic communities within the basin.
- Enforce regulations pertaining to water quality and quantity, enhance riparian corridors and improve instream habitat to help protect and enhance native aquatic communities within the basin.
- Evaluate potential for habitat improvement and reestablishment of Topeka Shiner's in the future.
- Conduct a mussel survey to better inventory the species and numbers found in the Crooked River basin.

Objective 3.2: Evaluate sportfish populations within basin streams and provide recommendations for maintenance and improvement of these populations to a level that satisfies the angling public.

Strategy: Assess the quality of sportfish populations and provide recommendations for the enhancement of populations through regulations, habitat improvement or stocking. A creel survey to determine angler use, harvest and attitudes should be done in the Crooked River basin. This information would be of utility in managing sportfish populations, and it would provide guidance for future management within the basin.

- Conduct a creel survey to determine angler use, harvest and attitudes in the basin.
- Develop a standardized sampling method and implement a monitoring program to collect trend data to be used in evaluating and managing basin sportfish populations.
- Identify critical habitats for sportfish at all life stages and maintain or enhance these areas as needed to increase production.
- Improve populations of sportfish through regulations and habitat improvements once population objectives have been determined.
- Increase awareness of the recreational potential of fishes other than sportfish such as common carp, suckers, buffalo, gar and freshwater drum through articles in local newspapers, outdoor magazines and/or a possible Missouri Conservationist magazine article.

Goal 4: Increase public appreciation for stream resources in the Crooked River basin.

Status: Most citizens in the region lack an understanding and appreciation for the importance of stream resources. There is little regard for the well-being of streams within the basin.

Objective 4.1: Increase the level of public understanding of local stream resources and proper stream management practices.

Strategy: Increasing public awareness and knowledge of stream values should result in improvements in the level of appreciation for local stream resources. Enhanced awareness of streams within the basin should result in heightened concern about stream quality.

- Promote formation of Stream Teams within the basin through contacts with local civic organizations and schools.
- Locate local streams within the basin that are near schools that also possess adequate access for field trips.
- Cooperate with the NRCS, Universities, and the MDC Outreach and Education Division in using local streams in the basin for aquatic education programs.
- Promote the values of stream resources within the basin through local newspaper articles, radio, and television.
- Evaluate streams in the Crooked River basin and nominate a reach for designation as an outstanding state water, and/or designated as an aquatic natural area (i.e. remnant prairie stream ecosystem).
- Promote trash dump clean-up and policing using school groups and stream teams.

Goal 5: Increase recreational use of streams in the Crooked River Basin.

Status: Turbid water, steep banks, intensively farmed land and limited access combine to limit recreation associated with basin streams. The Crooked River is not floatable at certain times and this also

discourages visitation. Scenic areas are found in the basin, and with restoration of wooded corridors, increased public awareness and better access, increases in use should be possible.

Objective 5.1: Increase recreational opportunities on and along streams within the basin.

Strategy: The MDC strategic plan calls for an increase in stream use to accommodate an overall increase in the level of use as construction of new reservoirs decline. Public satisfaction with existing recreational opportunities associated with streams in the basin needs to be determined. In addition, future acquisition sites, facilities and recreational opportunities should be identified.

- Conduct creel, recreational use and needs surveys periodically (at a minimum every 10 years) to determine public opinion and needs.
- Continue acquisition and development of stream access and frontage sites in the basin based on Stream Areas Program Strategic Plan and from Northwest Region MDC Fisheries staff recommendations. Acquire an access site near Elmira to allow canoeing on a Northwest Missouri stream when water conditions are optimum for floating.
- Increase recreational use at MDC sites in the basin using management plans tailored to take advantage of each areas natural features.

Objective 5.2: Recreationists have access to information on stream use opportunities in the basin.

Strategy: The public may not be aware of the recreational opportunities that currently exist in the basin. Publicity should increase use of basin streams. This in turn could lead to increased appreciation of the resource and foster the opinion that Crooked River basin streams are worth protecting.

- Publicize recreational opportunities in the Crooked River basin in the local newspaper, radio and television programs and the MDC's web page.
- Include information from the Crooked River basin in publications that promote hunting, fishing, floating, hiking and other activities related to stream resources.
- Emphasize stream resources at public events such as local sport shows, fairs, and National Hunting and Fishing Day.

Angler Guide

Crooked River

There are five stream access sites in the basin which offer some bank fishing and non-improved boat access. The access site on the lower portion of Crooked River has a concrete boat ramp. Channel catfish provide most of the angling opportunity in Crooked River. To catch channel catfish, fish around snags in the deeper holes of the lower river using natural or prepared baits. Largemouth bass and bluegill can also be found in fair numbers in the deeper holes of Crooked River. Fish around brush, snags, and rock outcroppings. Because Crooked River is a direct tributary of the Missouri River, the lower portion of Crooked River often contains a very diverse fish community, especially in spring. Carp, buffalo, gar, white bass, drum, flathead catfish, and other species can be common near the confluence with the Missouri River and provide seasonal fishing opportunities.

Ray County Community Lake and Lawson City Lake

Ray County Community Lake and Lawson City Lake are public fishing lakes in the basin. These lakes are approximately 25 acres in size, both have boat ramps, and both are disabled-user accessible. Both lakes typically provide good fishing for largemouth bass, bluegill, channel catfish, and crappie.

Glossary

Alluvial soil: Soil deposits resulting directly or indirectly from the sediment transport of streams, deposited in river beds, flood plains, and lakes.

Aquifer: An underground layer of porous, water-bearing rock, gravel, or sand.

Benthic: Bottom-dwelling; describes organisms which reside in or on any substrate.

Benthic macroinvertebrate: Bottom-dwelling (benthic) animals without backbones (invertebrate) that are visible with the naked eye (macro).

Biota: The animal and plant life of a region.

Biocriteria monitoring: The use of organisms to assess or monitor environmental conditions.

Channelization: The mechanical alteration of a stream which includes straightening or dredging of the existing channel, or creating a new channel to which the stream is diverted.

Concentrated animal feeding operation (CAFO): Large livestock (ie. cattle, chickens, turkeys, or hogs) production facilities that are considered a point source pollution, larger operations are regulated by the MDNR. Most CAFOs confine animals in large enclosed buildings, or feedlots and store liquid waste in closed lagoons or pits, or store dry manure in sheds. In many cases manure, both wet and dry, is broadcast overland.

Confining rock layer: A geologic layer through which water cannot easily move.

Chert: Hard sedimentary rock composed of microcrystalline quartz, usually light in color, common in the Springfield Plateau in gravel deposits. Resistance to chemical decay enables it to survive rough treatment from streams and other erosive forces.

Cubic feet per second (cfs): A measure of the amount of water (cubic feet) traveling past a known point for a given amount of time (one second), used to determine discharge.

Discharge: Volume of water flowing in a given stream at a given place and within a given period of time, usually expressed as cubic feet per second.

Disjunct: Separated or disjoined populations of organisms. Populations are said to be disjunct when they are geographically isolated from their main range.

Dissolved oxygen: The concentration of oxygen dissolved in water, expressed in milligrams per liter or as percent.

Dolomite: A magnesium rich, carbonate, sedimentary rock consisting mainly (more than 50% by weight) of the mineral dolomite($CaMg(CO_3)_2$).

Endangered: In danger of becoming extinct.

Endemic: Found only in, or limited to, a particular geographic region or locality.

Environmental Protection Agency (EPA): A Federal organization, housed under the Executive branch, charged with protecting human health and safeguarding the natural environment — air, water, and land — upon which life depends.

Epilimnion: The upper layer of water in a lake that is characterized by a temperature gradient of less than 1^{o} Celsius per meter of depth.

Eutrophication: The nutrient (nitrogen and phosphorus) enrichment of an aquatic ecosystem that promotes biological productivity.

Extirpated: Exterminated on a local basis, political or geographic portion of the range.

Faunal: The animals of a specified region or time.

Fecal coliform: A type of bacterium occurring in the guts of mammals. The degree of its presence in a

lake or stream is used as an index of contamination from human or livestock waste.

Flow duration curve: A graphic representation of the number of times given quantities of flow are equaled or exceeded during a certain period of record.

Fragipans: A natural subsurface soil horizon seemingly cemented when dry, but when moist showing moderate to weak brittleness, usually low in organic matter, and very slow to permeate water.

Gage stations: The site on a stream or lake where hydrologic data is collected.

Gradient plots: A graph representing the gradient of a specified reach of stream. Elevation is represented on the Y-axis and length of channel is represented on the X- axis.

Hydropeaking: Rapid and frequent fluctuations in flow resulting from power generation by a hydroelectric dam's need to meet peak electrical demands.

Hydrologic unit (HUC): A subdivision of watersheds, generally 40,000-50,000 acres or less, created by the USGS. Hydrologic units do not represent true subwatersheds.

Hypolimnion: The region of a body of water that extends from the thermocline to the bottom and is essentially removed from major surface influences during periods of thermal stratification.

Incised: Deep, well defined channel with narrow width to depth ration, and limited or no lateral movement. Often newly formed, and as a result of rapid down-cutting in the substrate

Intermittent stream: One that has intervals of flow interspersed with intervals of no flow. A stream that ceases to flow for a time.

Karst topography: An area of limestone formations marked by sinkholes, caves, springs, and underground streams.

Loess: Loamy soils deposited by wind, often quite erodible.

Low flow: The lowest discharge recorded over a specified period of time.

Missouri Department of Conservation (MDC): Missouri agency charged with: protecting and managing the fish, forest, and wildlife resources of the state; serving the public and facilitating their participation in resource management activities; and providing opportunity for all citizens to use, enjoy, and learn about fish, forest, and wildlife resources.

Missouri Department of Natural Resources (MDNR): Missouri agency charged with preserving and protecting the state's natural, cultural, and energy resources and inspiring their enjoyment and responsible use for present and future generations.

Mean monthly flow: Arithmetic mean of the individual daily mean discharge of a stream for the given month.

Mean sea level (MSL): A measure of the surface of the Earth, usually represented in feet above mean sea level. MSL for conservation pool at Pomme de Terre Lake is 839 ft. MSL and Truman Lake conservation pool is 706 ft. MSL.

Nektonic: Organisms that live in the open water areas (mid and upper) of waterbodies and streams.

Non-point source: Source of pollution in which wastes are not released at a specific, identifiable point, but from numerous points that are spread out and difficult to identify and control, as compared to point sources.

National Pollution Discharge Elimination System (NPDES): Permits required under The Federal Clean Water Act authorizing point source discharges into waters of the United States in an effort to protect public health and the nation's waters.

Nutrification: Increased inputs, viewed as a pollutant, such as phosphorous or nitrogen, that fuel abnormally high organic growth in aquatic systems.

Optimal flow: Flow regime designed to maximize fishery potential.

Perennial streams: Streams fed continuously by a shallow water table an flowing year-round.

pH: Numeric value that describes the intensity of the acid or basic (alkaline) conditions of a solution. The pH scale is from 0 to 14, with the neutral point at 7.0. Values lower than 7 indicate the presence of acids and greater than 7.0 the presence of alkalis (bases).

Point source: Source of pollution that involves discharge of wastes from an identifiable point, such as a smokestack or sewage treatment plant.

Recurrence interval: The inverse probability that a certain flow will occur. It represents a mean time interval based on the distribution of flows over a period of record. A 2-year recurrence interval means that the flow event is expected, on average, once every two years.

Residuum: Unconsolidated and partially weathered mineral materials accumulated by disintegration of consolidated rock in place.

Riparian: Pertaining to, situated, or dwelling on the margin of a river or other body of water.

Riparian corridor: The parcel of land that includes the channel and an adjoining strip of the floodplain, generally considered to be 100 feet on each side of the channel.

7-day Q^{10}: Lowest 7-day flow that occurs an average of every ten years.

7-day Q^{2}: Lowest 7-day flow that occurs an average of every two years.

Solum: The upper and most weathered portion of the soil profile.

Special Area Land Treatment project (SALT): Small, state funded watershed programs overseen by MDNR and administered by local Soil and Water Conservation Districts. Salt projects are implemented in an attempt to slow or stop soil erosion.

Stream Habitat Annotation Device (SHAD): Qualitative method of describing stream corridor and instream habitat using a set of selected parameters and descriptors.

Stream gradient: The change of a stream in vertical elevation per unit of horizontal distance.

Stream order: A hierarchical ordering of streams based on the degree of branching. A first order stream is an unbranched or unforked stream. Two first order streams flow together to make a second order stream; two second order streams combine to make a third order stream. Stream order is often determined from 7.5 minute topographic maps.

Substrate: The mineral and/or organic material forming the bottom of a waterway or waterbody.

Thermocline: The plane or surface of maximum rate of decrease of temperature with respect to depth in a waterbody.

Threatened: A species likely to become endangered within the foreseeable future if certain conditions continue to deteriorate.

United States Army Corps of Engineers (USCOE) and now (USACE): Federal agency under control of the Army, responsible for certain regulation of water courses, some dams, wetlands, and flood control projects.

United States Geological Survey (USGS): Federal agency charged with providing reliable information to: describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect the quality of life.

Watershed: The total land area that water runs over or under when draining to a stream, river, pond, or lake.

Waste water treatment facility (WWTF): Facilities that store and process municipal sewage, before release. These facilities are under the regulation of the Missouri Department of Natural Resources.

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